LIVING IN THE ENVIRONMENT:
a sourcebook for environmental education

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The book deals with urgent problems of environmental protection in the world and with ways to solve the problems in countries of various levels of socio-economic development. Necessary information on interdisciplinary aspects of the problem is available.

Intended for specialists in the field of the environment and for a wide range of readers. Recommended as a practical aid to teachers of universities and colleges, secondary and primary school.

20 figs. 39 tables. Refs: 202 titles.

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PREFACE

The progress and welfare of present and future generations depend, to a great extent, on positive and timely solutions to socio-economic and ecological problems which arise from the relationships between the human population and nature. It is this which has inspired the United Nations Educational, Scientific and Cultural Organization (UNESCO) to look anew at some of the major issues and problems characterizing the contemporary human environment.

A series of publications on contents and educational methodologies for different levels of the education system and varying audiences has been undertaken and the present sourcebook is one of this series. A collection of prototype environmental education modules, teacher-training modules, specific methodological guides and documents on strategies for programme formulation and curriculum development will also be published, including a companion volume to this sourcebook, a teacher's guide to environmental education, now in preparation.

These publications are part of the activities of the International Environmental Education Programme (IEEP), organized by UNESCO in co-operation with the United Nations Environment Programme (UNEP). The objectives of the programme are to co-ordinate and act as a catalyst for national, regional and international activities relative to implementing the recommendations of the Intergovernmental Conference on Environmental Education (Tbilisi, USSR, 1977), including the incorporation of the environmental dimension into education and training programmes, curricula, textbooks, and other instructional materials.

This sourcebook stresses the need for increased awareness of the relationship between people and their social, physical and natural environment and the need to increase the role of environmental education as a factor in the improvement of the environment. It is a survey of ideas that have emerged to date concerning various environmental issues and of a type of education whose purpose is to contribute to a better understanding of the human environment and to the solution of its problems.

It also contains information for use in education, which takes into account natural and socio-economic aspects of the environment. Its content is directed primarily at curriculum developers and university lecturers.

The sourcebook was prepared by a team of leading scientists and educators in the Ukrainian Soviet Socialist Republic with co-operation from UNESCO

specialists. K. M. Sytnik (Vice-President, Academy of Sciences of the Ukrainian SSR, Director of the Botany Institute), L. S. Cherednichenko (Rector of the Institute for National Economy Management), V. G. Sakhaev (Senior Research Worker of the Council for Studying the Productive Forces of the Ukrainian SSR, Academy of Sciences of the Ukrainian SSR), Yu. P. Lebedinsky (Vice-Chairman of the Council for Studying the Productive Forces of the Ukrainian SSR, Academy of Sciences of the Ukrainian SSR), V. V. Voloshin (Head of the Environmental Protection Sector, Presidium of the Academy of Sciences of the Ukrainian SSR) participated in the preparation of the book.

This sourcebook makes no claims to be an exhaustive work. It would not be possible to cover all aspects of the vast area of environmental problems and take into account every particular situation encountered throughout the world. For this reason, efforts to adapt the book at regional and subregional levels should receive particular attention, and UNESCO hopes that this effort will be continued by national study groups.

The ideas and opinions expressed in this book are those of the authors and do not necessarily represent the views of UNESCO.

The designations employed and the presentation of material in this work do not imply the expression of any opinion whatsoever on the part of UNESCO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

INTRODUCTION

The present period of human history is characterized by the rapid development of those productive forces through which the scientific and technological revolution, promoting socio-economic progress in every possible way, provides powerful means of affecting the environment. Natural resources have been intensively exploited for almost two centuries, without regard for the social consequences of economic activities. This has resulted in the reduction of wooded areas, in greater soil washoff, soil erosion, air, water and land pollution, damage to various species and, in a number of cases, changes in the biosphere which adversely affect human health.

The interaction of humanity and its environment has grown over the last few decades with the exploitation of nature on an increasingly large scale necessarily having a detrimental effect on the ecological balance. The field of production now involves practically all kinds of natural land resources and a considerable part of oceanic resources. Mankind has already used about 70 per cent of arable land, up to 80 to 90 per cent of natural pastures and nearly half of the wood increment in forests. Almost 90 per cent of the total population growth of the main commercial fish species are caught in inland rivers and water bodies. The annual output of minerals has reached 44 tons per capita throughout the world. Open-cast mining which causes degradation of natural ecosystems is the prevailing method in the exploitation of mineral resources.

World population growth is rising. For the last thousand years only the human population of the world has increased from 2 per cent per 1000 years up to 2 per cent annually.

Population growth, the accelerated development of productive forces, the ever-increasing involvement of natural resources in economic activity lead to the depletion and degradation of natural resources. There has been a sharp increase in desert and semidesert areas, with a corresponding reduction of forest areas and arable lands. Large numbers of animal and plant species have been exterminated. The reproduction capacity of fish has sharply diminished. In some countries, deposits of many minerals have been totally depleted.

In relatively extensive regions comprising individual countries or groups of countries the level of biosphere pollution has assumed threatening proportions. Each year, 140,000 million tons of CO_2 are released in the atmosphere, about 15,000 million tons being due to fuel burning and other types of economic activity [1].

Numerous estimates of likely variants in the demographic, economic, and ecological situation of the world between 1980-2000 point to an increase of waste products in both production and consumption and, consequently, an in-

crease in the level of environmental pollution. This sharp increase of waste products as well as the application of mineral fertilizers and chemical techniques for the control of weeds, pests and diseases in farm crops at an ever-increasing rate may lead to irreversible processes in the biosphere, to a deterioration in the quality of life. Thus, apart from finding solutions to local, regional and subregional problems of environmental control, there is an urgent need for a global solution to the key problem and, with this in mind, efforts are being made by many countries and peoples.

Among the key ecological problems of the world is conservation of the oceans and their biological resources. The time has come for mankind to soberly assess the ecological situation that has arisen in the "water-land" system and to show a constructive approach to the protection of the oceans — the original source of life and still the largest source of foodstuff. In this connection, the working out of integrated international programmes of water pollution control in the ocean proper as well as in the intracontinental rivers and water bodies is of the utmost importance. The establishment of a scientific system for the rational use, reproduction and control of the ocean's biological resources, control of industrial fisheries and of the output of different species of sea fauna is also of particular significance for environmental protection.

The problem of creating new highly productive ecosystems in arid and semi-arid areas is of great importance, and its solution also depends on joint action by many countries. Such a solution would make it possible to expand forest areas and sharply increase the output of agricultural produce.

Air pollution control is of exceptional importance in improving the ecological situation. Hence, the development of waste-free and smokeless production techniques and multifunctional purification installations for the generation of energy without air pollution acquires an ever-increasing significance in the economy of many countries.

The most important world-wide social and economic problems concerning the environment include the struggle against hunger, disease and poverty and the improvement of the living conditions of most countries of Africa, Asia and Latin America.

The standard of development and well-being of present and future generations largely depends upon positive and timely solutions to these problems. Relating these realities to the task of increasing the socio-economic and cultural development process, especially in developing countries, leads to a realization of the need for an entirely new approach to existing interrelations in the "humanity-environment" system.

It is also of crucial importance to take into account various aspects of environment control in primary and secondary education so as to teach the fundamentals of ecological information on the situation of the modern world and the possibilities of its transformation. Nevertheless, the presentation of this new subject in the existing curricula of a number of countries is based upon traditional methods of teaching regardless of the interdisciplinary and international nature of the problems concerned.

This situation may be largely explained by the inadequate training of teachers themselves and by a lack of necessary printed materials — reference books, manuals and teaching aids — through which it might be possible to inculcate basic information on the organic interrelationship between the natural and man-made environment, and on the importance of maintaining a permanent ecological balance as well as a sense of responsibility for the careful and rational use of natural resources.

Chapter I

ENVIRONMENTAL EDUCATION FOR UNDERSTANDING AND SOLVING ENVIRONMENTAL PROBLEMS

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CULTURAL HERITAGE AND ENVIRONMENT

Past Errors of Nature Protection Education

The failure to understand the place and role of man in the environment, and the absence among people in most countries of elementary knowledge on the development of the biosphere, taking into account the overall social, moral, economic and cultural heritages, necessarily influence the formation of negative views concerning the role of technological progress in social development. Among many trends of economic thought, a special place is occupied by the notion that the booming scientific and technological revolution on the threshold of the 21st century will lead to the end of mankind owing to the exhaustion of natural resources.

'Biosphere in Danger', 'On the Way to an Ecological Catastrophe', 'With an Axe at the Tree of Life', 'Civilization Will Die in 20 Years' — these were some of the sensational declarations that appeared in papers and magazines read by millions of people. Frightening facts and figures, numerous photos of polluted corners of the earth and bodies of water which have been turned into sewage ditches and many other things were flung at readers, conveying a terrifying picture of the end of mankind. The impression has been created, notes sociologist I. Bodamer, that the technical world promises to become even more frightening in the not too distant future than wild nature at its wildest.

It should certainly be borne in mind, that the recovery capacity of the ecosystem is not infinite. Quantitatively, the boundaries of biochemical pollution and the exhaustion and destruction of natural resources are far from having been completely studied. Nor is there a clear-cut answer to the question of the rehabilitative and adaptive possibilities of the human organism in these or other environmental conditions. Sooner or later, however, scientists will be able to propose an answer to this and many other questions. Hence, while there is no room for complacency, nor is there any reason to accept the inevitability of pessimistic prophecies. The main thing is to find the shortest path to a solution, the basis of which is a ramified network of teaching staff and untiring educational activity by teachers in environmental education, intended for all groups and strata of the population and taking into account the national aspects of existing systems of education.

Nature and Scope of Environmental Education

The nature of environmental education has evolved within the framework of an increasing awareness of the relations existing between man-made (social, cultural, political, economic, and technological) and natural (atmospheric, geological, biological and hydrological) systems.

Although environmental education has a rich heritage sometimes dating very far back, its renewal and unprecedented importance in the educational field result mainly from the awakening of public consciousness in the face of such serious problems as overpopulation, pollution, the use and availability of natural resources, and the general degradation of certain natural sites.

A study of the environmental education literature of the 1960s reveals little concern with integrating the environment into classical and nonclassical learning situations. There was no real attempt to give students a global picture of environmental problems and issues. From the 1970s onwards, however, the urgent character of environmental problems became more and more evident, and in recent years there has been a wide diversity of books and documents which refer indiscriminately to such terms as 'environmental education', 'ecological education', 'education for the environment', etc. Whichever the term, interest has been focused mainly on problems related to conservation of resources, preservation of plant and animal life, and similar themes.

However, traditional teaching limits itself to an anthropocentric conception of the environment and neglects the dialectics of the anthropophysical conception of man as part of nature. It now seems outdated to think of man as distinct from nature and as absolute master of the ecosystem. Logically, the natural environment and ecological aspects come first, since (a) the biophysical environment is and will always be the natural basis of man's existence, and (b) natural laws governing the biosphere and its processes function independently of human will, whether we like it or not. There is, however, no question of concentrating exclusively on the biophysical environment (which may simply lead to sterile research). The socio-cultural environment and the material environment are of equal importance, and it is essential to inculcate at an early stage the notion that 'people' and 'things' are equally important. Social and cultural as well as political and economic aspects of man-made environments can and should be integrated into environmental education programmes.

Environmental Ethics and Society

Some 60 years ago the Nobel Prize winner Albert Schweitzer argued that knowledge gives us power over the forces of nature. Profound changes are taking place in our living conditions. But progress does not mean that development is necessarily easier. We have made nature serve us. But at the same time we are divorcing ourselves from nature and this is fraught with many dangers.

We make the forces of nature serve the machine. In one of his books, Chuan Tsi tells how once a student of Confucius saw a gardener carrying water which he got from the well each time by lowering himself into it with a vessel. He asked the gardener if he wanted to facilitate his work. 'How?' asked the gardener. The student of Confucius answered: 'Take a wooden lever the front end of which is lighter and the other heavier. Then it will be easier to lift the water from the well. Such a well is called a well sweep'. The gardener

who was a wise man said: 'I heard my teacher say that if a man uses a machine he will work like a machine. He who works like a machine develops a machine heart. He in whose body beats a machine heart loses pure simplicity forever.' The danger which the gardener suspected, back in the 5th century B. C., has increased in our time to a frightful extent.

Purely mechanical work is now the lot of many of us. Torn from our homes and from mother earth, we live under conditions of depressing material enslavement. As a result of the revolution which came about because of the machine, almost all of us find ourselves in conditions of labour which strongly regulate and narrow our lives. It is not easy today to develop self-awareness and concentration. Our family life and the upbringing of children suffer. All of us, more or less, are threatened with becoming an item instead of a personality. Thus, the diverse material and spiritual damage inflicted upon man is the dark side of progress of human knowledge and practice. The very possibility of man to sustain the development of his own culture is called into question. Devoting themselves to the difficult struggle for existence, many have no strength left to think of cultural ideals. They no longer display objectivity; all their thoughts are directed only to improving their own lives. The ideals which they advance are accepted by them as cultural ideals and they thereby contribute to a complete confusion in the understanding of culture. In order to deal with the situation which has resulted from both positive and negative achievements of knowledge and practice, we should always think about the ideal of man and struggle against circumstances so that they will not hold back the development of man toward this ideal [2].

Today, when the moral and ethical aspects of environmental education have become the most important condition for success of modern world culture, this conclusion is more urgent than ever. It was from this point of view that the first Intergovernmental Conference on Environmental Education, Tbilisi, USSR, 1977, (hereafter referred to as the Tbilisi Conference) formulated the ultimate aim of environmental education as "creating awareness, behavioural attitudes and values directed towards preserving the biosphere, improving the quality of life everywhere as well as safeguarding ethical values and the cultural and natural heritage, including holy places, historical landmarks, works of art, monuments and sites, human and natural environment, including fauna and flora and human settlements" [129].

Eleven international documents have been adopted under the aegis of UNESCO since 1954 which promote the protection and rational use of cultural and natural monuments, and which, after ratification, become legislative norms especially important for developing countries. The Convention on the protection of the cultural heritage in case of military conflict (the Hague Convention) was adopted in 1954 and has been ratified by 66 countries. The Convention on prohibiting the importation and exportation of cultural treasures (natural research collections, archeological findings, paintings, sculptures, manuscripts and documents, postage stamps, antique furniture, musical instruments), adopted in 1970, was ratified by 38 countries. Of special significance is the Convention on the protection of world cultural and natural wealth (1972), in conformity with which an International Committee and Special Fund was set up to render international assistance in the study, restoration and protection of objects included in the 'List of the World Heritage' (12 regions, including 4 natural zones, which cover geological structures,

habitats of rare plants and animals, objects and complexes of great scientific and aesthetic value) [4].

Developments in Nature Conservation, Education and Environmental Policies

Environmentalism took root in the 19th century, but as a movement it was formulated at the turn of the 1970s. It is practised on a large scale in developed countries and in a number of developing countries.

In 1973, there were 20 thousand groups and organizations involved in environmental protection in the United States of America. Among them a leading role is played by the Environmental Protection Agency (EPA).

In the opinion of the Agency apart from economic and other hardships involved in fulfilling the requirements for environmental protection, difficulties arise from the complexity of the problems themselves and possible negative consequences of environmental protection measures. Thus, construction of powerful sewage treatment complexes resulted in an unexpected growth of cities. Among other environmental protection problems, the problem of chemical deterioration of the environment is especially important — more than one thousand new chemicals appear every year; in researching their toxicity, EPA comes up against the problem of industrial secrets.

In the Federal Republic of Germany 98 per cent of the country's population recognize the importance of environmental problems. Some two thirds of the population recognize the efficiency of public organizations for the protection and rational use of natural resources. The first of such organizations were set up at the end of the 1950s.

The report of the Federal Republic of Germany Gouncil of Experts on Environmental Protection Issues notes that during 1970-1978 considerably less money was spent than needed. Water and air pollution was greater than in 1970. That is why at the present time the environmentalist movement has been stepped up. A part of the country's population is expressing discontent with existing measures in the field. A number of projects have been carried out to transfer enterprises to other regions, primarily to coastal areas. These undertakings are financed through state subsidies. However, the pollution level in such recreation zones as the Lower Elbe area has now increased to that of the traditional industrial regions.

More than 10 years ago, all the groups in this field were occupied with concrete problems directly involving the interests of the inhabitants of various regions. After achieving success of recognizing failure (half of the organizations considered their activity to be successful) these groups ceased to function. The first interregional organization was set up in 1972 — the Federal Union of Public Environmental Protection Organizations, which united some 9,000 groups [6].

In France in order to implement effective environmental protection measures, it has been proposed to set up ecological groupings similar to that of trade unions [7].

Those countries where governments are really concerned about the condition of the environment, understand the benefits of investing funds in the eradication of illiteracy and ignorance among the population (especially in rural areas) and are concerned about questions of conservation and development of their economy and culture, will not leave a desert behind them. The situation is quite different in countries where little attention is paid to these issues, where the state and government, for various reasons, ignore the health of the nation, thoughtlessly exploit environmental resources and

are concerned only about immediate advantages and profits. The economic development of these countries gradually declines, becoming dependent on foreign 'aid', which leads to the degradation of national interests.

Notwithstanding the stepping up of environmental protection activity, there remain two diametrically opposite approaches to the solution of the problem in the world. One group of countries upholds the policy of the United Nations and UNESCO, and the other, for one reason or another, ignores the need to take account of natural resource factors in their socio-economic development and is essentially against environmental education and instruction. The reasons for the rejection are mainly financial and, as a rule, reflect purely private interests.

Nonetheless, if we compare the present situation with that of ten or fifteen years ago, we notice a trend towards gradual comprehension of the problems and recognition of the full importance of environmental education in those countries which for many years denied its significance for the skilful utilization of what had been achieved by science and technology for the further development and improvement of people's living standards.

This thesis is now convincingly confirmed by the expanding network of international organizations, institutions and media which in one way or another are connected with environmental education problems. Within the United Nations these include: the United Nations Environment Programme (UNEP); the United Nations Educational, Scientific and Cultural Organization (UNESCO); the United Nations Children's Fund (UNICEF), the Food and Agriculture Organization of the United Nations (FAO); the World Health Organization (WHO); the International Labour Organization (ILO); the United Nations Development Programme (UNDP); the International Bank for Reconstruction and Development (IBRD); and the United Nations Institute for Training and Research (UNITAR).

The number of non-governmental organizations has also increased significantly. Mention should be made of the International Union for Conservation of Nature and Natural Resources (IUCN); the World Nature Conservation Fund (WNCF); the International Youth Federation for Environmental Studies and Conservation (IYE); the International Council of Scientific Unions (ICSU); the International Nature Conservation Fund; the International Coordinating Committee for Education and Non-Formal Research; the International Council on Education for Teaching (ICET); the World Confederation of Organizations of the Teaching Profession; the International Environment Protection Centre; the International Assembly of Non-Governmental Organizations on the Protection of Man's Environment; the International Consultative Union for Developing the Educational Programmes on Natural Sciences and Mathematics; the International Union of Associations for Education in the Field of Natural Sciences; the International Consumers' Organizations; the World Council of Churches (WCC); the Organization for Economic Co-operation and Development (OECD); etc.

Co-operating in the field of environmental education in Europe and North America are: the Council for Mutual Economic Assistance (CMEA), the European Economic Community (EEC); the Council of Europe, the Northern Council of Ministers for Education and Culture, the Union for Environmental Education, the National Association for Environmental Education; in South America: the Organization of American States (OAS); in the Arab States: the Arab Educational, Cultural and Scientific Organization (ALECSO), the Arab

Institute of Economic Development and Planning; in Asia: the Asian Centre for Education and Reorganization; the South-East Asian Ministers of Education Organization (SEAMEO), the United Nations Economic and Social Commission for Asia and the Pacific, (ESCAP) *, the Asian Biological Education Association; in Africa: the Institute of Economic Development and Planning, the African Fund for Fauna Conservation, the African Social Studies Programme (ASSP), the Association for the Training of Teachers for Africa, the Comité inter-état de lutte contre la sécherease dans le Sahel, the African Programme on Natural Science Education, etc.

Various seminars, conferences, symposia and meetings of specialists from different countries are held regularly with the direct participation of these organizations or under their auspices, for the exchange of opinions and discussion of important environmental education issues.

Environment and Development — a New Approach to Education

A special role in establishing general principles of environmental education was played by the Symposium on Environmental Education, Switzerland (1966), the Intergovernmental Conference of Experts on the Scientific Basis for Rational Use and Conservation of the Resources of the Biosphere, France (1968), the Conference on Conserving Recoverable Natural Resources, Argentina (1968), the Conference of Teachers, Kenya (1968), the International Workshop on the Place of Nature Conservation Education in Educational Programmes in Schools (1970), the European Working Conference on Environmental Protection Education, Switzerland (1971), the Conference of Environmental Education at University Level, France (1971), the Conference of the Organization of American States on Environmental Education Issues in the Countries of America (1971), the United Nations Conference on the Human Environment, Sweden (1972), the International Seminar for Environmental Studies in Higher and Secondary Teacher Training Schools in the United Kingdom and Canada (1972), the Conference of North-Western Countries of Europe on Environmental Education in Elementary Schools, the Netherlands (1972), the Seminar on Environmental Education, Finland (1974), the Conference on Environmental Education, Denmark (1974), the International Workshop on Environmental Education, Belgrade Yugoslavia (1975), hereafter referred to as the Belgrade Workshop, the Tbilisi Conference, etc. The five-language newsletter **Connect**, published by the UNESCO-UNEP International Environmental Education Programme (hereafter referred to as IEEP) since 1976, which reports on efforts by environmental education specialists in many countries, has been conducting extensive instructional and informational work on environmental education at the international level.

The renewal of this education owes much to individuals, institutions and programmes which have supported its cause and succeeded in arousing public concern. In the past, however, they generally conducted their activities exclusively in the name of conservation. Recently the need for more radical environmental action has confirmed the limitations of that approach, leading to the necessity of interpreting environmental education in a wider and more practical context than that of conservation alone.

Environmental information and interpretation consist in explaining to the

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* Formerly the United Nations Economic Commission for Asia and the Far East (ECAFE).

general public the relationship between man and the environment in order to widen perception of the environment and awaken the will to contribute to its preservation and improvement. This is usually done in reference to a specific site, where interpretation is aimed at making visitors aware of its importance and the need to protect it.

What is the distinction between environmental education and environmental interpretation? What are their common characteristics? Both are concerned with clarification of environmental concepts and the study of environmental values as well as attitude development, but environmental interpretation emphasizes the latter while environmental education gives greater importance to the acquisition of skills.

Notable changes have taken place in the very treatment of the essence and content of environmental education, the conception of which has undergone substantial changes in accordance with the degree of environmental knowledge dissemination, and has changed from an abstract philosophical conception into a practical programme of action.

A noteworthy aspect is the consistency of views on the very idea of education and on the elaboration of various conceptions:

1968 — The constructive approach to the environment, both philosophically and pragmatically has not yet become an integrated part of thinking and action. This remains the basic task in the field of environmental education [8].

1970 — Environmental education is a process of recognizing the value and various conceptions with the aim of determining the skills and approaches necessary for understanding the connection between man, his culture and the biophysical environment. This involves the adoption of decisions and the elaboration of a code of behaviour relating to the quality of the environment [9].

1971 — Environmental education includes teaching on determining certain values and the ability to clearly think of complicated environmental problems which are as much political, economic and philosophical, as they are technical [10].

1972 — The Intergovernmental Conference on the Rational Exploitation and Protection of Biosphere Resources focuses attention on the special significance of, and need for, a well-organized teaching of environmental science at given stages of study both for extending general information, and as a basis for training future specialists.

1974 — Environmental education is a way of reaching environmental protection targets and is not a separate branch of science or a special subject of study. It should be included in the entire lifelong educational process [11].

1975-1977 — Although several problems are evident and some common aims are clear, there still is no common view of what education in the field of the environment represents, what the teacher should know and do, and, more important, how man should treat the complicated and ever-changing environment to which he belongs.

... environmental education is still at the developmental stage. Although some of its roots go far back into the past, it is basically a new sphere and therefore it is possible to elaborate a number of successive approximations or estimations only taking into account how it will be developing during the coming decade [12].

... the future of our air, water, soil, forests and mineral resources in the long run depends on the relations between man and nature. And that is why we believe it very important that every person be versed in environmental problems through proper education in the environmental field. Environmental education also has great significance for the integration of knowledge.

Another important field, where thanks to the corresponding forms of environmental education, a deeper understanding of environmental problems became especially noticeable in the past few years, is development itself, as well as the proposed establishment of a new international economic order. The study of relations between the environment and development has led to a more complete understanding of the fact that the aim of development should henceforth include, among other things, a continuous improvement of the quality of life, the eradication of poverty, a fair participation of people in the benefits of development. The problem does not consist in how to make a choice between environmental protection and the achievement of development goals, but in how to direct the course of development in such a way as to ensure maximum environmental benefits for present as well as future generations. In essence, the relationships between the environment and development is a key issue, and for a more complete understanding of these relations it is necessary to have a more profound idea of environmental education [3].

Environmental education is an educational concept which considers the environment as a scientific and aesthetic resource to be used in a lifelong educational process, thus making people knowledgeable and aware of the environment and its problems as well as their own role in environmental conservation, preservation and management.

Environmental education should be thought of as a process which takes place **for** and **in** the environment. By **for** we mean that the objective of all education, and of environmental education in particular, is to enable the individual to fulfill his potentialities and aspirations while acquiring a sense of responsibility and commitment with regard to the improvement of environmental quality for the benefit of all humanity. **In** expresses the fact that all resources of the environment itself should be used in the educational experience. It should not be forgotten that environmental education evolves around three central themes, each of which represents a particular stage: (1) education in which the environment represents a means, (2) education concerning the environment, and (3) education of the individual as a person living in an environment of a given quality and who is partly responsible for that quality.

The primary objective is to explain to everyone the complex reality of the natural and built environment and to stimulate in individuals and societies a commitment to a form of environmental management which starts with observation of the effects and proceeds to act on the causes of environmental deterioration in order to ensure the harmonious development of the quality of life.

Environmental education is a fundamental process through which persons at all possible educational levels (present and future citizens) become aware of, and concerned with, the environment and its related problems, and acquire the knowledge, skills and determination needed to solve those problems. It is based on ecodevelopment, i. e. scheme of action which is linked with undertakings in virtually every field and which could very well constitute a means of initiating and consolidating a new orientation for human development. In this sense, environmental education is a vast and multi-interdisciplinary pedagogical approach which involves all kinds of institutions and individuals. It is a process which enables us to acquire an understanding of the complex nature of the environment of which we are a part, and to appreciate humanity's dependence on, and responsibility for, this environment. It is

a means of achieving the goals of environmental management.

However, environmental education is not aimed solely at the conservation and management of external resources or the study of nature, though these aspects could form part of an environmental education programme. Nor is it a distinct branch of pedagogical science or a subject matter to be added at great expense to overloaded curricula. It is rather a new educational approach to the relations of people and their environment: it is an experience-based education which uses the totality of physical, natural and human resources of a milieu as a learning laboratory. It is an interdisciplinary approach which links each subject of study to a united goal which is applicable to the earth as a whole, an approach centred on life, oriented towards community development and aimed at the training of responsible, motivated and self-confident citizens. Geared towards the development of models of behaviour of lifelong value, environmental education is a rational process meant to improve the quality of life.

The Tbilisi Conference clearly defined the goals of this education as (a) to foster clear awareness of, and concern about, economic, social, political and ecological interdependence in urban and rural areas; (b) to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment; (c) to create new patterns of behaviour of individuals, groups and society as a whole towards the environment [129].

It follows that environmental education forms part of all thought and all cultural action in its widest sense; its principle is a strategy which presupposes knowledge of the natural sciences, technology, history and society, as well as the intellectual capacity to analyze and synthesize with a view to creating new functional patterns. It takes into account the quality of life, along with the objectives to be attained in this respect and the means at the disposal of humanity to maintain the level of this quality.

In addition, environmental education implies that ecological principles should be taken into consideration in the diverse activities of social and economic planning at the national and international levels. There should be, simultaneously, a vast global action resulting from world unity and more specific actions concerning the environment and its problems at the local level. However, while environmental education gives prime importance to a problem-solving approach, it is at the same time essentially or multi-interdisciplinary, i. e. it concerns all problems, disciplines and issues related to the natural and man-made, ecological and social, political and economic, cultural and aesthetic environment. The notion of global, lifelong democratic education has evident repercussions on the conception and organization of environmental education. Since this education should be lifelong and available to all, it should be introduced at all educational levels — primary, secondary and university. It should constitute a single continuous and organic process which neglects none of the essential phases of integration.

The essential principle of environmental education is that, through it, each individual can and should acquire the knowledge and skills which enable him to participate in all decisions needed in problem-solving and to share in a responsible way in the planning and management of a democratic society. Thus environmental education constitutes an effective instrument for giving a new orientation to the overall concepts of teaching and learning, as well as a more 'human' character to education as a whole. In this view, it should

go beyond the limits of a single course or curriculum; it should be presented clearly as a lifelong process, leading to a new mode of teaching and a new art of living for all.

By its nature and function, environmental education forms an integral part of society. It should address itself to all members of a community and use procedures in line with the needs, interests and motivations of the various age groups and socio-occupational categories.

The Tbilisi Conference considered three categories of those receiving environmental education: first, the general public: this education should be provided at every age and at all levels of formal education, for pupils and teachers, and in various non-formal activities, for young people and adults, including the handicapped; second, specific occupational or social groups: this education is focused on those whose activity and influence have an important bearing on the environment, for instance, engineers, architects, administrators and planners, industrialists, trade-unionists, policy-makers and agriculturalists. Various levels in formal and non-formal education should contribute to this training; and third, certain professionals and scientists: this training is for those working on specific problems of the environment, such as biologists, ecologists, hydrologists, toxicologists, soil scientists, agronomists, foresters, landscape architects, oceanographers, limnologists, meteorologists and sanitary engineers. It is important that the training of scientists include an interdisciplinary component [129].

The integration of environmental education programmes is likewise a principle of capital importance. They should not be limited to educational institutions but should be elements of a lifelong educational process incorporated in the context of social and economic reforms. Moreover, they should not be designed according to a single model, since environmental education must respect regional and national differences, it should be adapted to, and draw its substance from, circumstances, human resources, cultural and socio-economic conditions. Methodologically, therefore, diversification of approaches is a prerequisite for success.

Environmental education must insist on the value and necessity of local, national and international co-operation with a view to solving environmental problems. It must be stressed, however, that the most convincing declarations, the most preserving efforts of international (governmental and non-governmental) organizations, are worthless in the absence of a national political commitment. Governments have a crucial role to play in a field in which the most urgent tasks consist in establishing objectives, deciding on strategies and mobilizing the vital forces of a nation, its material, human and financial resources, in order to make of environmental education an element for the necessary transformation of society.

To understand correctly the significance and practical relevance of environmental education needs and priorities in a given country, it is essential to know first, how the country itself perceives and takes care of its environment; and secondly, the role and functions of education in the society concerned. The need to elucidate these considerations so as to ensure an adequate understanding of environmental education practices in each country stems from the fact that educators in most countries have to develop courses and teaching methods adapted to local needs and conditions on the basis of excessively general definitions of the 'environment'.

The Tbilisi Conference endorsed the following guiding principles. Environmental educatian should

consider the environment in its totality — natural and built, technological and social (economic, political, cultural-historical, moral, ethical);

be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and non-formal stages;

be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;

examine major environmental issues from local, national, regional and international points of view, so that students receive insights into environmental conditions in other geographical areas;

focus on current and potential environmental situations, while taking into account the historical perspective;

promote the value and necessity of local, national and international co-operation in the prevention and solution of environmental problems;

explicitly consider environmental aspects in plants for development and growth;

enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;

relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;

help learners discover the symptoms and real causes of environmental problems;

emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem-solving skills;

utilize diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment with due stress on practical activities and first-hand experience [129].

These guidelines indicate that environmental education is a process which inculcates values and elucidates concepts so as to develop those skills and attitudes needed in understanding and appreciating interactions between man and his environment. This education stimulates civic action, decision making and the elaboration of a personal code of conduct with regard to problems concerning ecodevelopment and the quality of life. From the integration of environmental education aspects, formal education will gain a renewed vigour which will open up wider horizons, and non-formal education, whether in the home of the community, will acquire greater responsiveness to social needs. However, since environmental education is innovative in every respect, it implies a reorientation of existing knowledge in function of real problems and community needs. This necessitates the revision of curricula, teaching methods and certain educational structures, concerning which much remains to be said.

Environmental education is a newly created field. The conclusions and reports of UNESCO conferences and meetings such as the Tbilisi Conference, the Belgrade Workshop, the regional meetings held in 1976-1977 in Africa, the Arab States, Asia, Europe and Latin America, as well as several subregional meetings and workshops, have helped considerably in clarifying environmental education concepts and in formulating recommendations and proposals for future action.

The Tbilisi Conference made evident to all the necessity of developing an education of people for people, since 'the protection and enhancement of the environment for present and future generations has become a primordial objective for humanity'. If education is to play an essential role in the awakening of environmental consciousness, then it

should be noted that the environment has the power to induce education to play this role by obliging it to take into account the diverse evolving forces and evolutionary processes. What comes out clearly in the Declaration of the Tbilisi Conference is the urgency of 'action in favour of environmental protection' and, even more the need to place education at its service.

Environmental education is now a well-established reality of constantly increasing importance, although its interpretation and implementation vary. A certain number of problems are evident and certain objectives have been clearly defined, but there are still differences of opinion regarding content and methods: what the educator should know and how he should act and above all, how humanity can face the challenge of the complex, constantly changing environment in which it is plunged.

It should be stressed that no single group, nation, culture or school of thought can claim to have all the solutions to problems engendered by interaction between economic development and the quality of life, within the environment. However, environmental educators constitute perhaps the first group of specialists to feel concerned with the [illegible] of all [illegible] new [illegible] of [illegible] but also of people in the context of [illegible] environmental awareness.

A study of world literature on environmental [illegible] aims, it is particularly important to create a system allowing a clearer exposition of the goals and objectives of this education.

Environmental education aims at the acquisition of knowledge, values and skills with a view to solving environmental problems. Here, the environment is taken as a whole and the objectives apply to the natural as well as to the man-made — including the socio-economic and political — environment. Consequently, although the range of possible environmental education objectives is practically limitless, some of these receive particular emphasis in current specialized literature and practice. They were formulated by the Tbilisi Conference as follows:

Awareness: to help social groups and individuals acquire an awareness of and sensitivity to the total environment and its allied problems.

Knowledge: to help social groups and individuals gain a variety of experience in, and acquire a basic understanding of the environment and its associated problems.

Attitudes: to help social groups and individuals acquire a set of values and feelings of concern for the environment, and the motivation for actively participating in environmental improvement and protection.

Skills: to help social groups and individuals acquire the skills for identifying and solving environmental problems.

Participation: to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems [129].

The fundamental idea is that through education the individual can acquire the knowledge needed to make decisions and solve problems, thus allowing him to participate, in a responsible manner, in the planning and management of a democratic society.

The principal objectives of environ-

mental education mentioned above represent the highest ideals of the entire educational process; in a way, all education should be an education for the environment, in the recent and complete sense of this term

Taking into account the listed requirements, national systems of education should be set up adaptable to local conditions of development, peculiarities [illegible] [illegible] cation is shown in Fig 1 [13].

Global concern about the world's environmental education development and [illegible] basis of activities of the International [illegible] (IEEP), created by UNESCO in co-operation with UNEP

The results which can be attributed to the action of IEEP in the last seven [illegible] ment of a general awareness of [illegible]

As regards general awareness of the [illegible] tems — which, before 1975, was a mat[illegible] thin a limited number of industrialized [illegible] finds an echo in all regions of the [illegible] States, 26 [illegible] North America)

Among IEEP's actions contributing most to the development of a global environmental education awareness was [illegible] ference. In this connection, the Belgra[illegible] America, and Latin America, contribu[illegible] different regions. The Tbilisi Conference, as mentioned, culminated the series, [illegible] environmental education at the international level as well as for the development of national strategies and the promotion of international co-operation. ([illegible] involved in the Tbilisi Conference, the [illegible] and in the seven regional and subregional environmental education training [illegible] from international organizations, 57 from Africa, 53 from the Arab States, 45 from Asia, 614 from Europe and North America, and 121 from Latin America.)

At the national as well as the international level, 25 pilot projects undertaken in all regions by IEEP since 1977 have sensitized populations to environmental problems and facilitated [illegible] dimesion into the national education [illegible] en in Africa, two in the Arab States, [illegible]

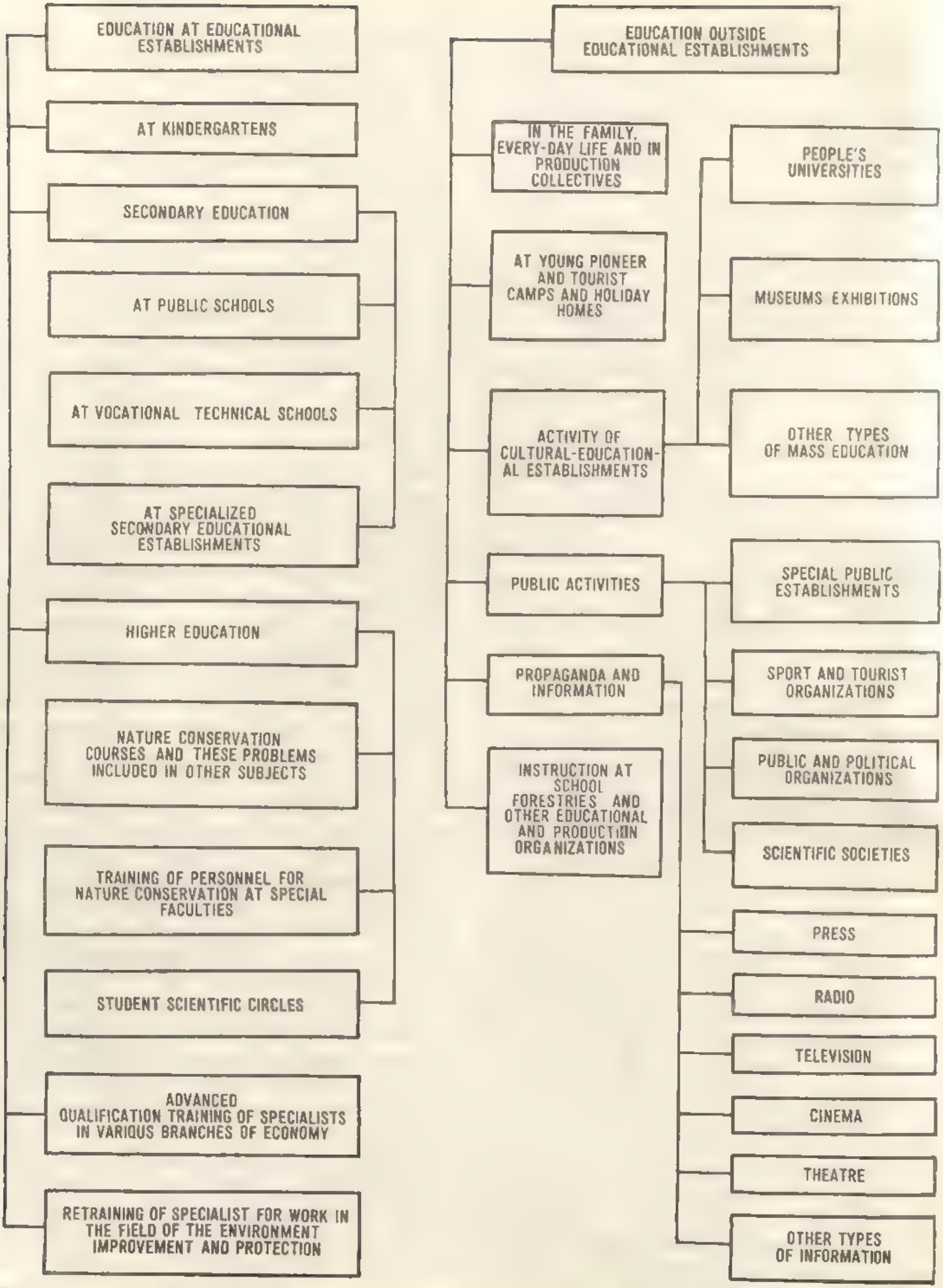

Fig. 1. System of education in the environmental field (according to Mitryushkin et al., 1980).

policy makers and professionals in environmental education, IEEP has been steadily building up a computerized information system which is compatible with that of many other agencies and institutions. The data base at present contains information on 900 institutions and 300 environmental education projects for publication in regularly updated directories (the newest is planned for the end of this year). The directories are also planned in English, French and Spanish, the descriptions indexed by keywords involving a special thesaurus which has been developed for environmental education.

A policy of regular, periodical information has also contributed considerably to international awareness of environmental education, notably through IEEP's international newsletter **Connect**, which appears in five languages and is distributed to about 12,000 individuals and institutions of the five world regions who are actively involved in the promotion and development of environmental education and training.

The conceptual and methodological clarification of environmental education itself has been another important aspect, that is a clearer definition of the substantive or thematic content of environmental education as well as the ways and means specifically favouring its conduct and implementation. The contribution of the IEEP in this regard has been fundamental. Through the workshops, seminars and pilot projects which were organized in all regions of the world, the working documents and final reports issuing from them and widely distributed, key personnel have been made acquainted with environmental education as a perspective to be incorporated into all subject matter of the educational process. Participants and others have also had their vision enlarged regarding the environment as a totality — natural and built, ecological, political, economic, technological, social, legislative, cultural and esthetic — and the necessity of including all these aspects of the human environment in the process of educating for its preservation and improvement.

Similarly, IEEP has stressed the interdisciplinary approach taken by environmental education so as to effectively contribute to the solution and prevention of environmental problems in their multiple aspects. In this connection, IEEP supported an important international seminar on interdisciplinary environmental education at the primary and secondary levels, which was held in Budapest (Hungary, 10 to 14 November, 1980). IEEP has also emphasized the need for involving all sectors of the population, school and community, in the environmental education process, particularly local problem solving. Lastly, all publications of the Programme, including its newsletter and books, such as **Environmental Education in the Light of the Tbilisi Conference,** contain and help disseminate widely these conceptual and methodological approaches and orientations.

In addition to its contribution to general awareness of environmental education and its concepts and methodologies, IEEP has significantly aided efforts of Member States concerning the **incorporation of an environmental dimension into their educational practice,** both inside and outside the formal school system. Since the inception of the programme in 1975, a number of states have officially introduced environmental education into their educational plans, policies or reforms through new legislation or appropriate institutional arrangements. In many instances, they have established ministerial or interdisciplinary committees as a follow-up to the regional meetings, national training courses, research activities or pilot projects undertaken or supported by IEEP, which have directed or guided

the incorporation of environmental education into their formal and non-formal education systems. (As a direct or indirect result of the IEEP's activities, a number of Member States have initiated or developed legislation related to environmental education, among them are: Colombia, Costa Rica, France, Indonesia, Mongolia, the Ukrainian Soviet Socialist Republic, the USSR, the United States, Venezuela, and others.)

The contribution of the programme to the above incorporation of environmental education into general educational practice has, more particularly, involved three areas: the development of curricula, the elaboration of instructional materials and the training of teachers.

With respect to teacher training in environmental education, IEEP has developed since 1976, and more intensively since 1978, seven regional and subregional training workshops in Africa, the Arab States, Asia, Europe, Latin America and the Caribbean for such educational personnel as curriculum developers, administrators, researchers and teacher trainers. These workshops have dealt with questions related to the establishing of national environmental education policies, the development of pre-service and in-service teacher training systems and the development of quidelines for the preparation of local educational materials. Teacher-training courses and pilot projects involving a training component have also been initiated or supported at the national level. (In co-operation with Member States, IEEP has resulted in thirty national training workshops: eight in Africa, two among the Arab States, seven in Asia, five in Europe and eight in Latin America.)

As for educational contents, methods and materials relating to the environment, IEEP has developed a series of research activities on methods and contents and as a result a coherent set of didactic materials, including methodological guides and sourcebooks for teachers, as well as a series of modules for the training and retraining of teachers and for the conduct of environmental education at the primary and secondary levels. Local adaptation of the teacher training-modules has been initiated. Complementary to these core elements, surveys and guides have been developed which are devoted to problems of methodology particularly relevant to environmental education, such as use of the modular approach, use of simulation, and approaches and methods for the evaluation of environmental education practices. A multilingual glossary has been prepared, as well, to standardize internationally current environmental education terminology. Special documents have also been developed for each training workshop.

In summary: IEEP has prepared two major publications on the contents and methodologies of environmental education; four studies concerning interdisciplinary approaches; gaming and simulation, evaluation and modular approaches, two world surveys on environmental education curricula and training systems; six modules for pre-service and in-service environmental education training of teachers and six modules for environmental education in formal school systems.

Lastly, the 25 pilot projects described earlier have not only aimed at sensitizing decision and policy makers to the necessity of environmental education, but also at training groups of teachers at the national level and developing materials suitable to the local environmental situation and condition.

In conclusion, one might mention the multiplying effect of IEEP. Since its inception, it has been working in co-operation with United Nations agencies and other international governmental as well as non-governmental organizations. In October 1974, UNESCO

convened the original meeting of representatives of these bodies and various regional experts for the purpose of helping to construct the framework of a global environmental education programme. Based upon the recommendations of this meeting and follow-up consultations, UNESCO prepared and submitted the initial three-year project to UNEP, which was approved in January 1975 and from which IEEP emerged. There have subsequently been many formal and informal meetings, including joint programming sessions, convened and presided over by UNEP, between all the organizations involved.

In the same spirit of co-operation and exchange of information pertaining to environmental education, there are frequent reports in bulletins and newsletters of the above agencies and international bodies concerning activities of IEEP and, reciprocally, reports of their environmental education actions or publications in the programme's newsletter. The programme has also helped to inspire a number of new international magazines and revues, which draw on **Connect** for many of their items on environmental education developments throughout the world, as do many educational, scientific and other journals and periodicals.

Of particular importance in terms of impact and influence have been the international meetings organized directly by IEEP, most notably the Belgrade Workshop and above all the Tbilisi Conference, which have become landmarks and reference points for those engaged in the development of environmental education, from government policy and decision makers to practising teachers. Recommendations of the Tbilisi Conference have been particularly relevant to ministerial level planning and programming they have been cited as authoritative by such intergovernmental bodies as the Council of Europe, CMEA, OECD and others. There is similar reference in virtually all courses, articles, books and publications concerned with environmental education, whether internationally, nationally or locally.

NATIONAL PARTICULARITIES IN ENVIRONMENTAL EDUCATION

Interdisciplinary Character of Environmental Science and Differences in Teaching Methods

Children acquire the foundation of a sound environmental attitude from an early age through the joint efforts of the family and pre-school educational institutions. Their future perception of the environment as they advance in their education depends on how painstakingly and thoughtfully parents approach the fostering of a love for nature, animals and plants. If the family is indifferent to the environment and takes only a consumer's point of view towards it, then few environmental education programmes will be able to fill the gaps in the child's environmental instruction, which plays a primary role in the formation of an environmentally aware individual. A most important requirement for parents is that they themselves have a proper attitude towards the environment and in good time encourage their children to develop an understanding of harmony with the natural world. The programme in preschool establishments should be based on these principles, which help awaken in children the awareness and sympathy which form the foundation for a later environmental ethic and morality.

However, the main role in the entire education process belongs to elementary and general schools, vocational and technical schools and specialized secon-

dary education establishments. The school should foster in students an understanding of environmental problems and the tasks facing society from the standpoint of the biological balance in nature, the physical factors of the environment, the production of material and spiritual benefits, the formation of moral standards and a humane attitude to nature. Generally, schools create among young people an individual attitude to the environment which reflects one or another ideology. It is important that this attitude be based on a complete system of education taking into account the main aspects of environmental education. These include: cognitive contact with nature; the historical context of man's activity; the scientific basis of relationships with the environment; forms of ownership of natural resources and means of production, as well as economic, juridical, sanitary and hygienic, moral and aesthetic aspects of the environment.

An obligatory condition for a complete approach to environmental education is the successive integration of various environmental study courses in history, geography (physical and economic), biology, physics, chemistry, social studies, zoology, botany, natural history, literature, fine arts, music and other disciplines, taking into account the age level of the students and the educational medium.

Satisfaction of the above requirements depends on the time factor and on the quality of the corresponding educational programmes. Hence, considering:

that the separate disciplines which may bear on environmental issues are often taught in isolation from each other and may tend to neglect or pay insufficient attention to environmental problems,

that separate as well as interdisciplinary approaches both have parts to play, depending on situations, learning groups and age levels,

that interdisciplinary approaches are essential for the enhancement of environmental education,

that interdisciplinary approaches cannot be achieved without the active participation of teachers,

that the interdisciplinary or integrated approaches cannot be effectively implemented without the simultaneous development of instructional materials,

that research relevant to these different approaches, aspects and methods is needed to provide a sound basis for the development of environmental curricula and programmes,

that institutions for such research variously require development of support,

the Tbilisi Conference recommended:

that the relevant authorities initiate, continue and strengthen — as circumstances may require — their efforts for incorporation of environmental issues into the various disciplines and subjects of the formal education system;

that institutions engaged in the development of curricula, teaching programmes and materials for environmental education study the problems linked with single subject, multidisciplinary and interdisciplinary approaches respectively; consider the suitability of each approach to different situations and learning groups; and identify the potentially most effective contributions of, for example, the natural sciences, the social sciences and technology;

that relevant institutions be encouraged to concern themselves with programmes of initial and in-service training for teachers,

that research and development programmes be preferably problem- and action-oriented;

that in areas of special significance for the historical and cultural heritage, policies of environmental education be accompanied by positive strategies for socio-economic development [129].

Thus, the interdisciplinary character of the subject itself is the cornerstone of the entire environmental education process. Support of this strategical line is a prerequisite for reaching the set goal.

Fundamentals of Environmental Education and Rational Use of the Environment in the Union of Soviet Socialist Republics

In primary and secondary schools considerable experience has been accumulated in the USSR in teaching the fundamentals of protection and rational use of the environment. In the first year of primary school, continuing the programme of preschool establishments, pupils regularly observe nature, and register weather conditions in journals. While so doing, they cultivate consideration for the environment and continuously learn about the most important patterns in animate and inanimate nature. Contact with animals and plants helps children to develop profound feelings about the world aroud them.

In the second and third years, the boundaries of perceiving nature and the rational use of natural resources are expanded with the help of such subjects as natural history, excursions and practical studies during school and out-of-school hours. Participation in the landscaping of the school territory, work in orchards and forests, excursions to local ethnographic museums, etc. give pupils their first appreciation of the need for a rational approach to the national heritage. The knowledge obtained is decured in various forms as lessons, including those in the fine arts, singing and literature.

In the fourth to tenth years, environmental instruction of pupils is carried on in accordance with recommendations of the Research Institute of Content and Methods of Teaching under the Academy of Pedagogical Sciences of the USSR. The course of natural history in the fourth year is a basis for the future development of knowledge.

When studying the topic 'Water', the pupils' attention is centered on the increasing level of sea, ocean, river and lake pollution from industrial and municipal wastes. It is stressed that this is in voilation of existing legislation. Basic preventive measures on the reduction of pollution of the oceans are set out in general terms.

The subject 'Air' concisely establishes the role and importance of air for the existence of man, animals and plants. The teacher uses examples to explain the harmful effects of air pollution on all living organisms, he describes how pollution occurs and what should be done for the purification of air, and gives a list of basic measures for the protection and rational use of atmospheric air in towns and at industrial enterprises. Special attention is given to the role of green spaces in the improvement of the urban atmosphere and to the part assigned to school-children in plant conservation.

The topic 'Mountain Rocks' gives basic information on available mineral deposits. The pupils learn that no matter how great the volume of mineral extraction, deposits of coal, iron ore and oil are dwindling, as a result of which practical measures are being taken to make their use in the national economy more efficient. It is especially important to strive for complete use of the extracted fuel and power resources and for the curtailment of losses. A leakage of natural gas, for instance, deteriorates the quality of the atmosphere, and a leakage of oil on land or sea leads to the destruction of plants and animals.

The topic 'Soil' considers questions of soil conservation and the need to prevent its exhaustion as a result of poor cultivation and excessive pasturing of

cattle, which lead to the deterioration of the plant cover, development of erosion and formation of ravines. Pupils learn that snow retention and care for forest shelter belts conserve the soil and preserve its nutrients.

The subject 'Plants, Animals and the Environment' deals with the need to keep the air, water bodies, river and lakes clean — all with a view to protecting the plant and animal kingdoms. Here the pupils acquaint themselves with rare and endangered species of animals and plants and with conditions favourable to their survival.

In biology lessons, along with a study of traditional aspects of the conservation of plants, minerals, birds and rare animals, pupils are for the first time given an idea of ecological systems and the varied relationships between animate and inanimate nature. The influence of economic management on different ecological processes is taught and pupils are given a list of basic measures for maintaining the ecological balance in nature.

From the study of botany, pupils learn about the relationships of plants with the surrounding world and about the importance of vegetable products for Human life. For instance, when taking up the topic 'Roots', pupils discover a connection between plants and soil. The importance of observing the established standards of fertilizer application is emphasized.

The topics 'Leaves' and 'Plant Communities' deal with the role of plants in enriching the air with oxygen and in making the vegetative biomass productive, depending on the amounts of heat and humidity as well as on the types of soils in various natural zones. Using examples of cultivated plants, the teacher acquaints pupils with the possibility of raising the bioproductivity of the vegetative mass. The same topics include discussion of measures for the recovery and reproduction of vegetation resources, including the observance of established norms of felling; the ban on pasturing cattle in forests; the sowing and planting of wood species; the planting of green shelter belts and the carrying out of sanitary felling; the care of forest stands; the planting of greenery in cities and other populated areas; the observation of patterns of behaviour in recreational zones, etc. In connection with great losses caused by fire, pupils are systematically reminded of the importance of correctly handling fires in forests, steppes and on peat beds.

In zoology, environmental protection aspects of teaching are ensured by a study of animal ecology. Pupils receive more information on the relations between different organisms and the environment, on morphological and physiological adaptation of animals to certain factors of the environment.

The topics 'Protozoa Type', 'Flatworm Type', 'Nematode Type' and 'Anthropode Type' deal with efforts to reduce the number of certain species of animals such as disease carriers (malarial parasites, mites, parasitic worms), bloodsucking insects, agricultural and forest pests. The characteristics of mechanical, agrotechnical, chemical and specially biological methods of decreasing the number of these species are briefly outlined.

In studying the topics 'Class of Fish', 'Class of Birds', 'Class of Mammals', and 'Distribution of Animals on the Earth', pupils receive information on the impact of various branches of the economy on natural food chains and other relations in the structure of ecological systems.

Simultaneously, they learn about ways of making rational use of world animal resources and rules and regulations concerning commercial animal hunting. Using as an example the biology of certain species (sable, moose, muskrat), pupils are told of the neces-

sity for strictly observing hunting norms as a condition for the rational use and expanded reproduction of animals. Pupils learn about government measures for increasing the number of commercial species; acclimatization, reacclimatization, organization of large-scale specialized farms (fish factories, animal farms); measures for direct protection (conservation) of living nature resources; temporary bans on the use of certain species or their populations; and the preservation for scientific and cultural purposes of certain species in reserves and national parks.

Special attention is paid to scientific knowledge of ocean productivity. In studying the areas of intensive fishing (for instance, the North Atlantic) and the development of the modern whaling industry, pupils come to realize how fast the resources of the world's oceans are being exhausted due to irrational use.

In anatomy, physiology and human hygiene lessons, hygenic health factors of the environment are set forth as part of the conditions for the normal existence of a human organism.

Under the topic 'Respiration', teachers stress the importance of keeping constant the gas composition of the air for the normal functioning of respiratory organs and the entire organism of man. Information is given on local changes in the chemical composition of air basins leading to photochemical smogs in large cities and industrial centres. The importance of international co-operation in preserving the purity of the planet's atmosphere is emphasized.

The topic 'Nervous System and Senses' touches upon social factors which affect the health of the population, above all the effects of noise pollution on the nervous system.

The ultimate goal of general biology lessons on patterns in the formation of the biosphere and the complicated set of relations between animals and plants extends an understanding of the natural science aspects of environmental protection.

The topics 'Cell Study' and 'Origin of Life on the Earth' disclose the role of plants as converters of solar energy into energy of chemical bonds, which resulted in the present gas composition of the atmosphere.

The topic 'Patterns of Variability' deals with the mutagenic effects of radioactive and chemical pollution of the environment on the human genetic apparatus, and the appearance of mutagenic forms of bacteria and viruses causing animal and plant diseases.

A great deal of environmental education information is contained in the topics 'Organism and Environment' and 'Biosphere and Man'. While studying these subjects, pupils learn about the productivity of ecological systems, the biomass of land and ocean, and about the many different ways to utilize them, first and foremost, for increasing foodstuffs and raw material resources. Pupils come to appreciate that environmental protection is an important socio-economic problem and that the present generation bears a considerable responsibility in the matter.

The natural science and economic aspects of environmental protection are included in the corresponding physical and economic geography lessons, through which pupils acquire the necessary minimum of scientific knowledge for the origin and development of nature components and their combinations forming various nature complexes. Studying these subjects, pupils become acquainted with the use of natural resources in countries with different social systems. They become aware of the indissoluble ties between the development of technical progress and environmental protection seen from the viewpoint of their social function and on this basis ensure a steady improvement of the living

standards of the entire population. Of great importance is the conception of renewable and non-renewable resources and their quantitative assessment wherever they occur.

In chemistry and physics lessons, pupils are taught the fundamental principles of present production, which helps them to understand the economic, hygienic and health-improving aspects of the environment in close unity with the legal aspects of a given problem. They are told (and examples illustrate this) that the indispensable condition for all modern technical processes is the ecological character of production, meaning the relationship between technological processes and the environment which excludes negative effects on the biosphere. Violation of this principle testifies to the non-progressive character of a particular technology.

In chemistry lessons emphasis is placed on the rational use of waste from chemical and petrochemical industries with contribute considerably to the total volume of environmental pollution.

The topic 'Water, Bases, Solutions' examines the property of water as a natural solvent and its use in industry (dissolution of chemical waste), in agriculture (dissolution of fertilizers, pesticides), in the household (dissolution of detergents and other synthetic substances). The compounds thus formed are often not included in the natural cycle of substances but are accumulated in different media, in plant and animal organisms, and can adversely affect vital processes.

Becoming acquainted with the fundamentals of the production of chemical products (sulphuric and nitric acid, mineral fertilizer, organic substances), pupils learn about the harmful effects of this production on the environment and the measure designed to prevent these effects.

Environmental problems are also examined in the school's physics course from the viewpoint of the ecological character of production. In studiyng the properties of communicating vessels under the topic 'Gas and Liquid Pressure', pupils acquaint themselves with the application of these properties in operating locks in hydroelectric station dams, equipped with special lifts for fishes swimming upstream for spawning.

The economical operation of hydroelectric stations greatly depends on the artificial water reservoirs which ensure a constant reserve and pressure of water for the turbines. At the same time, the creation of man-made seas, in many cases, leads to the flooding of highly productive agricultural lands and subsequent eutrophication caused by a heavy growth of blue-green algae. Hence, pupils are told that the construction of hydroelectric stations is expedient when the ecological and economic benefits of the flooded agricultural land is lower than the ecological and economic benefits of the station's construction and the generated electricity.

Under the topic 'Movement and Forces' sixth year pupils studying forces of interaction learn about the role of soil capillarity in moisture retention and transmission. The regularities of liquid evaporation, revealing that the rate of evaporation depends on the temperature of the liquid, the area of evaporation surface and the movement of air above it, show the role of forest belts and forest park lands for retaining moisture in the soil, namely, that they create a wind shadow over the fields, thus lessening the intensity of the wind, which cuts down the evaporation of moisture from the soil surface.

In the seventh year, the topic 'Heat Phenomena' explains the physical nature of microclimate formation in regions around man-made water reservoirs and large natural water bodies.

Great attention is given in the tenth year, under the topic 'Nuclear Energy', to questions of radioactivity and envi-

ronmental protection from radioactive radiation.

In history lessons, in the study of the main stages in the formation of the state, pupils examine the methods used to solve nature protection problems in the Russian state before the October Revolution and their essentially new solution under socialism.

In social studies, pupils receive extensive general information on major environmental protection concepts, mainly of a legal, moral and civic character. They learn the role of natural resources and development of production forces and one of the most important advantages of socialism — the planned character of the use and renewal of environmental resources, a natural basis for the development of the national economy and improved material, cultural and other values.

Considerable possibilities for environmental education can be found in the literature and art studies courses.

The above does not exhaust the teaching of the bases of protection and rational exploitation of the environment in the USSR. An ever-greater role is being played by optional classes, the 70-hour programme of which includes the following:

Introduction. Nature protection — a set of government, international and public measures aimed at the rational use, renewal, multiplication and conservation of natural resources for the good of mankind. Nature protection and care of public health (purification of air, water and green spaces).

Scientific bases of nature protection. The impact of economic management on nature in different historical epochs: primitive, slave-owning, feudal, and capitalist systems. Nature protection under socialism. History of nature protection.

Forms of man's impact on nature. Interrelations in nature. Direct and indirect influence of man on nature. National customs, superstitions, religion and their significance for the conservation of plants and animals.

Major nature protection problems. Significance of nature protection. First measures taken by Soviet power for nature protection. Conservation of forest and other green spaces. Conservation of wildlife. Reserves and their role in nature research and conservation.

Present state of nature protection:

1. Atmospheric air control. Changes in air composition caused by human activities. Measures for atmospheric air control.

2. Water purity control and its significance for modern towns and countryside. Water pollution from products of human activity. Pollution of the oceans. Pollution and purification of underground waters.

Practical studies. Trips to industrial enterprises equipped with smoke catchers and treatment facilities. Trips to forests for studying springs. Sampling of natural freshwater sources. Clearing of debris from springs. Planting of alder and willow trees along the shores of water bodies. Work of the 'green patrol' headquarters in protection of plantings.

3. Soil conservation. Soil is the national treasure of the country. Soil erosion. Measures for soil erosion control. Ravines and their prevention. Forest planting for field protection.

Practical studies. Trips to places where soil washoff is taking place. Listing of all ravines in the local microregion. Planting of trees and shrubs in slopes, ravines and their banks. Planting trees and shrubs in former peat beds, planting forest shelter belts in woodless regions.

4. Plant protection. Significance of forests, their distribution on the planet and specifically in the USSR. Reduction of forest areas. Rational use of forests

and their protection. Forest fires and their prevention. Forest pests and pest control. Green spaces and their conservation. Forestation in the USSR.

Practical studies. Trips to forests to study the flora. Work in forests according to school forestry plans. Trips to study forest pests and means of biological pest control (involving insectivorous birds). Planting trees and shrubs along the streets of towns and villages, laying out squares in wastelands, planting of forest belts along roads.

5. Conservation of fish and other animals. Fish resources and their use. Poaching and its prevention. Pollution of water reservoir and fisheries. Fish breeding. Work of 'blue patrol' headquarters.

6. Protection of land animals. Significance of birds and mammals in nature and the economy. Possibility of using wild animals and crossing them with domestic animals. Animals destroyed by man (Steller's cow, wingless loon, passenger pigeon, auroch, etc.). Protected animals and those in need of protection. Animal protection principles. Protection and multiplication of the number of bison. Conservation of commercial animals and birds. Specially protected animals: onager, saiga, Persian gazelle, wild boar, moose, beaver. Conservation and reacclimatization of beaver, sable, marten and raccoon. Stocks of fur-bearing and hoofed animals and their conservation.

Practical studies. Trip to study the animals and birds of the vicinity. Placing of salt-lick for hoofed animals and gravel for granivorous game birds. The hanging of log hives for bats. Preparation of twig fodder for hoofed animals.

Winter trips to study the tracks of animals and birds and their life at this time of the year. Reviewing films.

7. Protection regulation of non-commercial birds. Utilization of insectivorous birds. Significance and protection of birds of prey and fish-eating birds.

Practical studies. Trips to study the songs and lives of birds. Imitation of natural nests and their distribution in forests. Creation of feeding places for birds, storage of food for wintering birds. Ringing of birds as an assignment of ornithological stations.

8. Protection of inanimate nature monuments (caves, geysers, etc.). School and nature protection. The role of pupils in nature protection. Holidays: 'Forest Day', 'Hello, Forest', 'Golden Autumn', 'Holiday of Flowers', 'Bird Day', etc. Work of young naturalist clubs. School forestries and their role in fostering a love for nature and choosing a profession. Organization of the work of 'green' and 'blue' patrols. Nature and poetry.

Environmental Education in Certain Developing Countries

In recent years, an understanding has been growing in developing countries that teaching and education at all levels should correspond better to the needs of society and reflect the specific features of their natural, economic and public development.

The content of environmental education in developing countries differs fundamentally from that in industrialized countries in that the attainment of even the minimal level of life is connected with an increase in production and activization of consumption. A main goal for developing countries lies in organizing consumption and a more equitable distribution of all that is produced. Proceeding from this, environmental education should mainly reflect the concepts and technological solutions which are oriented to the management of resources and envisage an increase of the volume and quality of goods and public services.

Another distinctive feature of this education is connected with determining the place played by traditional education in environmental protection in the overall educational structure. That is why the cultural and socio-economic character of these countries should be taken into account. In this connection it is necessary to work out a unified environmental education programme. But there is still no unanimity on this issue. In Kenya, for instance, two approaches to environmental education are practised. One of them envisages interdisciplinary education, the other is based on teaching a separate environmental education course in secondary schools.

The government of Kenya is pursuing an active policy in the field of environmental education. One of the subcommissions of the National Secretariat for Environmental Problems under the President and financed by the government, works out curricula for teaching environmental protection, prepared various data, organizes conferences and seminars and conducts broad instructive programmes among the population. The Department for National Parks, the Ministry for Tourism, the National Museum, the Kenya Association of Nature Conservation Clubs, the Fund for Nature Conservation Management, the National Academy and University are rendering practical assistance to the subcommission. Close ties have been established between the subcommission and UNEP, which provides it assistance and financial support, IUCN, as well as the World Conference of Organizations of the Teaching Profession (WCOTP).

This structure, together with the study of alternatives for satisfying Kenya's need for power resources, leads to a more appropriate exploitation of forests and to a better use of agricultural land. The experience of Kenya is being successfully adopted by a number of other developing countries.

Special note should be taken of the fact that general education and government environmental undertakings in Kenya are not just a short-term campaign, but a continuously improving educational programme for students, school-children and specialists which is conducted with due regard for local environmental conditions and relationships. Since 1964, an environmental education centre has been functioning at the Nairobi National Park, and the Kenya Association of Nature Conservation Clubs was organized in 1968. Two seminars on the training of teachers and improving the methods of integrated environmental education were held in 1974 in co-operation with the Science Education Programme for Africa (SEPA), UNEP and WCOTP. Taking into account the merits of Kenya in the field of nature conservation, the UNEP Headquarters was located in Nairobi in 1973 and the National Secretariat of Kenya for Environmental Problems was founded in 1974. In 1976 a special model school using advanced environmental education methods was opened.

In Zambia primary school pupils receive elementary information on the geography of the country and protection of its natural resources. In secondary school, lessons are conducted through the course titled 'Environmental studies'.

According to **Connect** (December 1979 and March 1980 issues), many of the countries of Asia consider environmental education as an integral part of general education. On the whole, the creation of additional institutions for solving problems connected with environmental education has not been recognized as expedient at the primary and secondary level of education where this task is usually fulfilled by existing centres for the development of curricula. But the need for environmental protection and corresponding scientific research has brought about an increase in

the number of universities engaged in this field. One of the programmes for preschool and primary levels of education was begun more than 10 years ago in Burma, where industrial pollution was less than in other Asian countries. The programme 'Environment' does not call for textbooks and is based on direct study 'in nature'. In Bangladesh there is a similar programme called 'Muktangan' or 'Open Air Study'. It was begun as an experimental demonstration project in 1976. It is planned to disseminate its results on a broader scale [16].

In most countries of Asia, improvement of the quality of life and development are a prime concern. Environmental degradation is caused mainly by underdevelopment and its accompanying poverty. Evidence of this is found not only in insanitary urban slums and hovels and impoverished rural habitats but also in the growing numbers of unemployed and illiterates, in overexploited soils with dwindling agricultural productivity, in grasslands grazed to destruction, in forests denuded of trees by excessive logging, and in the activities of international conglomerates.

Viewed against this background, general acceptance of environmental education in Asia may be ascribed to the emergence of two complementary concepts. On the one hand, education as a vehicle for transmission of societal values and knowledges must emphasize harmonious living with the environment. On the other hand, the developmental aspirations of the society must also find their expression in national education programmes. Acceptance of these complementary concepts as the basis of environmental education in Asia implies that the environment is to be considered in its totality, including its natural, man-made, socio-economic and cultural aspects, while harmonious living with the environment is to be recognized not as a maintenance of the status quo, but as a process of dynamic evolution in which development takes place in harmony with the environment.

Ideally, environmental education programmes in the Asia and Oceanian region are to be evaluated in terms of their effectiveness in the implementation of these dual objectives. In practical terms, the main objectives of environmental education are to create awareness about the total environment as an integrated system, about interrelationships and interactions between the component subsystems and about the alternatives available to individuals as well as to society when undertaking activities affecting the environment; to develop values and attitudes and provide motivation for protection and improvement of the total environment: and to help acquire the skills necessary to undertake these environmentally related activities.

In most countries of Asia, environmental education is treated as a dimension of general education and its incorporation within the general curriculum is achieved by reorganizing and integrating the separate disciplines, and by emphasizing and enlarging their environmental content. Generally, it has not been considered necessary to build additional infrastructures to implement environmental education programmes at the primary and secondary levels, the task has usually been carried out by existing curriculum development centres. However, the necessity of carrying out environmental surveys and research and the need to train the personnel required for implementation of environmental projects have led to the development of infrastructures devoted entirely to one or another aspect of environmental studies at the territorial level.

A number of special activities have been conducted in Latin America within the framework of environmental education directed to the training of engineers and specialists of ecological profile. In the case of Costa Rica, an entire

programme of higher education in the field of environment has been put forward. In Venezuela, eight universities have been involved in the programme and, as a result, with the aid of consultant experts, effective measures have been taken to introduce environmental concepts into engineering curricula and also to develop a general course on the environment for all first-year students. In Brazil, the fact that the programmes coincided with an important national reform of curricula for higher technical education opened up the possibility of incorporating the environmental dimension as well as relative elements of the humanities and social sciences into reformed curricula.

Behind current programmes and activities for the development of environmental education in Colombia is an established environmental policy which includes a National Development Plan, an Ecological Code and a series of educational reform decrees of the Ministry of Education. The Plan is directly concerned with the environmental impact of development measures; the Code has led to the creation of a commission dealing with the evaluation and effective application of environmental education. The Ministry of Education itself has undertaken an educational reform which has meant incorporating principles that have found agreement at international, Latin American and other conferences. This involves goals, objectives, content and materials as well as ways and means of introducing the environmental dimension into the education system.

Implementation of environmental education programmes in Colombia takes a variety of forms. Training workshops for personnel concerned with the development and dissemination of programmes are organized in co-operation with the National Institute for Renewable Resources and the Environment (INDERENA). At the formal level, environmental themes have been explicitly integrated into the curricula of the new, experimental programmes for pre-school and primary education, especially in social and biological sciences. The environmental component has been emphasized in the health and nutrition programmes which are being tested throughout the nation, and similarly in the educational part of the Integrated Rural Development Programme which aims at adequate environmental education for agricultural workers and farmers. In the small village school, where there is often only one teacher, environmental education has been made a factor for greater coherence and motivation.

In adult education programmes, the immediate environment is made use of in a number of ways. For one thing, it is a point of reference in literacy courses for discussions revolving around the learner's own problems and experiences as well as a source from which a basic vocabulary is effectively constructed. For another, the immediate environment provides the core of real interests and needs in such subject areas as family, health, housing, production, consumption, recreation and social organization.

In out-of-school environmental education, various activities are undertaken and a variety of methods, materials and media are employed. Posters and 'wall newspapers' are used by teachers for adults as for children both outside and within the formal school system. Television programmes, directed by the Division of Nonformal Curricula, occasionally deal with environmental themes. Days are [illegible] organized around ecological themes with activities organized under INDERENA's auspices. More than 5,000 pupils and teachers have participated in such 'days' which are still in an experimental stage. The environmental concern shown by the mass media and many organizations has resulted in the coordination of activities

in this regard. A research project of considerable importance has been undertaken in the vast area of eastern Colombia (Orinoco and Amazonia) and has laid the basis for corrective environmental education and action for the development and conservation of these regions.

A fundamental aspect of the national education system has been a programme prepared by the Ministry of Education's Directorate General for Training which ensures the environmental education training of teachers. The Division of Nonformal Curricula, which is responsible for environmental education projects, has elaborated and published a framework for these projects that is widely used in Colombia as a basic document of reference. As for implementation of environmental education at the university level, three national meetings are being organized in this regard under the sponsorship of the Colombian Institute for Higher Education.

Similar activities have been started in Brazil, Costa Rica, Cuba, Venezuela, etc. All this demonstrates that environmental education in developing countries is itself at the stage of development.

Training of Teachers for Environmental Education

A large number of teachers graduated at a time when questions of environmental education were not given due attention. In this connection, the environmental training of qualified educational personnel has been considered as a 'priority activity' by the Tbilisi Conference. The Conference further stressed 'the establishment at the national level of a programme of action aiming, on the one hand, at familiarizing teachers and educational administrators and planners with different aspects and problems of the environment and, on the other hand, at giving them a basis of training which would enable them to incorporate environmental education effectively into their respective activities. This action should take the form of both pre- and in-serivce training' (Tbilisi Final Report).

With regard to personnel training, the Tbilisi Conference recommended: that environmental sciences and environmental education be included in curricula for pre-service teacher education..., that... in-service training of teachers in environmental education, be made available to all who need it; that environmental training be practical and relate to areas in which teachers will or already work; and that educational and training institutions have the necessary flexibility to enable them to include appropriate aspects of environmental education, within existing curricula and to create new environmental curricula that meet the requirements of an interdisciplinary approach and methodology. The following reports on the status of teacher training in environmental education in different regions are based on an extensive survey on teacher training conducted by IEEP in 1979-1981 (see **Connect**, December 1981).

The survey of the teacher training situation in Africa covered the following areas and countries: West Africa (Ghana, Liberia, Nigeria, Sierra Leone, Upper Volta), East Africa (Ethiophia, Kenya, Tanzania, Uganda, Zambia) and Southern Africa (Lesotho, Swaziland, Zimbabwe). The results indicate that four out of the thirteen countries have teachers with environmental education training (a total of about 306), the vast majority of whom are in East Africa. There is general agreement that there is not a sufficient number of adequately trained teachers for the region.

There is no formal environmental education in teacher-training colleges, but in West and East Africa especially there is an environmental component in

such subject fields as food, water, air, land conservation and population growth and an attempt at integrating courses in general with the environment as one of the integrating themes. In Southern Africa environmental education is mostly conducted through parent meetings at schools and through schoolchildren themselves.

Respondents indicated that the problems encountered in incorporating environmental education into the curricula of teacher-training colleges were largely due to (1) a lack of appreciation of the importance of environmental education a shortage of adequately trained teacher educators, (3) too little scheduled time in crowded programmes, (4) insufficient environmental education materials for teacher use, (5) inadequate opportunities for field studies and (6) lack of funds.

Solutions proposed, in addition to meeting the above shortcomings, involved a national policy for the inclusion of environmental themes in existing disciplines, development of new syllabuses with environmental components, orientation toward community education on local environmental problems and their solution, and organization of seminars and workshops, particularly for in-service environmental education teacher-training.

The general picture presented by all countries revealed a need at the ministerial and interministerial level for development and support of national policies for introducing or strengthening environmental education in schools generally and in teacher training institutions in particular. Stress was also emphasized the establishment of regional teacher-training institutions to help meet national needs, lacks and shortages in environmental education.

Environmental education is relatively new and the environmental education programmes of many Arab States have been strongly influenced by programmes sponsored by UNESCO and ALECSO, in co-operation with UNEP. There is general recognition on the part of Arab educators of the importance of preparing teachers who are motivated and capable of incorporating the environmental dimension into the various disciplines.

The two principal institutions for preparing teachers of the Arab States are the teacher-training institutes and the universities. Teacher-training institutes generally admit students who have passed the secondary education certificate examination (in Oman, the intermediate certificate is required). These students are qualified after two years instruction to be teachers in primary schools. As part of their study, they engage in practice teaching so as to be familiar with the syllabuses they will use after graduation. These syllabuses place varying emphasis on environmental concerns, according to the country. Most teacher-training institutes pursue programmes that deal with some environmental issues in the different disciplines.

In Bahrain, special lectures and seminars in environmental education are conducted for student-teachers. In both Bahrain and Qatar, teacher-training institutes have been annexed to universities (forming the nucleus of the Gulf University in the case of Bahrain), which means that the qualification of teachers has been raised to the university level. In Kuwait, two courses in environmental education are being given to student-teachers. There is a plan in Oman to introduce environmental education into teacher-training institutes in the very near future which will coincide with the new emphasis on environmental concernes to be incoroprated into schools syllabuses.

As regards universities in the Arab States, the environmental education situation is generally the same except for the fact that university graduates

are prepared in education and academic faculties to teach in intermediate and secondary schools. In most universities, environmental issues are taught in different disciplines rather than in an interdisciplinary manner, leaving it to the students to integrate the knowledge from different fields. Some universities, however, deal with environmental issues in a more integrated fashion through special lectures or courses.

The Education Faculty of Ain-Shams University, Cairo, for instance, offers environmental education lectures for students who, upon graduation, teach in secondary schools. Various disciplines are combined to deal with specific environmental problems and some research work is done in environmental education for Diploma, M. A. and Ph. D. degrees. For several years the Abha College of Education, Saudi Arabia, has provided a special environmental education course which covers all aspects of the natural and man-made environment. Qatar University similarly offers a special environmental education course, titled 'Man and the Biosphere', with lectures covering all the goals and objectives first formulated in the Belgrade Charter. In Kuwait University, a course on 'Man and the Environment' was introduced several years ago as obligatory for such university faculties as engineering, law, humanities and science.

Although some Arab States had already introduced environmental concerns into their school programmes, most states undertook to do so following the regional environmental education meeting held in Kuwait, November 1976, in the framework of IEPP (see Connect, March 1977). Among the recommendations of the meeting was the in-service environmental education training of teachers, which was deemed to be of immediate priority.

As a follow-up to the regional meeting, orientation programmes were organized in many Arab States for school supervisors and heads of departments, so as to introduce environmental education aims and objectives in the teaching of various disciplines. In turn this key personnel undertook, and is still undertaking, on-the-job environmental education of teachers.

Scientific environmental education remains a relatively new educational practice and there is a scarcity of professors in teacher's colleges who can conduct environmental education training programmes, ALECSO has organized regional teacher-training workshops in collaboration with various universities (Ain-Shams, Alexandria, Bagdad and Yarmouk), sent a travelling team of experts to a number of states and issued a variety of publications with UNESCO-UNEP support (sourcebooks, teachers, guides, etc.). The team-teaching approach in a biology project conducted by ALECSO has served as a model of interdisciplinarity and integration.

The involvement of teachers in national environmental education projects outside the school has been of great benefit. An example is that of the water purification project in Jordan's Ghore area, where IEEP co-operated with the Jordanian Ministry of Education at the intermediate school level (see **Connect**, May 1978).

Present emphasis in the pre-service environmental education of teachers in Europe and North America varies from traditional disciplinary, passive learning to direct-experience, interdisciplinary strategies.

Although documentary findings are scarce in the affective domain, it appears that most of the activity in this aspect of environmental education is included as a part of the coursework in general environmental study curricula. It is generally recognized that environmental education involving pre-school

and early primary school children should concentrate on the emotional aspects of environmental appreciation. However, countries report little that indicates extensive efforts to increase teacher awareness of the environment as a means of enhancing their effectiveness in imparting environmental sensitivity to the younger students or to students in upper class level.

In Czechoslovakia single discipline study is found down to nursery school level. Here student teachers are taught to use the overall framework of school studies to impart a more holistic environmental view. The emotive aspect of environmental education is sometimes worked into social and humanistic studies in upper elementary and secondary teacher environmental education. It is included in the curricula dealing with such topics as human society, social studies and philosophy.

Some teacher education schools in Norway have found that training in team teaching methods is an effective means of positively affecting teacher values. There is currently a need to equip teachers with the physiological and sociological fundamentals of social change skills so as to prepare them for dealing with values education in the classroom.

In many European countries environmental study is usually covered as part of the traditional teacher education courses, especially in the natural and social sciences (France, the Netherlands, Norway, the USSR). Topics relating to the human and biophysical environment are also included in numerous other non-environmental courses: outdoor recreation, chemistry, economics and others. Ecological studies are often included as a segment of biological studies coursework.

Specific emphasis on ecological and environmental studies is given in such courses as ecological ethnological theories, energy flow and human environmental relations, nature protection and environmental education. Much of the pre-service environmental education of teachers in the United States and the USSR is provided through studies in traditional disciplines or visits to rural nature centres for field study.

Although there are some encouraging aspects of environmental education study in teacher education colleges, most of the courses are discipline oriented. Integration of environmental topics is left to individual students. In addition, a heavier emphasis is usually placed on cognitive environmental knowledge in the late primary through secondary grades.

One exemplary programme, at Lancaster University, United Kingdom of Great Britain and Northern Ireland, allows prospective environmental education teachers to develop these skills through heavy reliance on feedback following trial runs in the classroom and a flexible independent study programme. There are, however, few universities offering teacher education in problem-solving skills. It is usually for the teacher, following cognitive environmental education training, to develop his or her own abilities to deal with and teach effectively environmental problem solving.

In the United Kingdom environmental studies methodologies have been taught at teacher-training colleges since the 1960s. The Federal Republic of Germany includes environmental protection in general methdologies education. Many other countries still lack effective programmes in environmental education methodologies. Canada in particular recognizes a great need for pre-service teacher education in environmental education methods.

Environmental studies increasingly emphasize involvement in local problems and real-life approaches through a variety of teacher education methodologies: investigations (United King-

dom), field study (France, the Netherlands, the United Kingdom), community involvement (the United States and the USSR) and in-class teacher training feeback to the student teacher (the United Kingdom). Those countries which realize the value of first-hand teacher education experiences but do not at present make extensive use of such techniques (e. g., Canada, Italy) are attempting to incorporate more of these approaches into the environmental education teacher programmes.

Studies of real situations offer many opportunities for greater interaction between teachers and students. Many countries recognize that effective environmental education must stress empathy between teacher and student. A need for more direct student involvement has been outlined by experts at international meetings on environmental education. In order to meet these challenges teacher education in environmental education methodologies must focus on the teacher and students as a learning team.

Many teacher institutes recognize the need for interdisciplinary methodological training, but there are few programmes providing for this need. Traditional, discipline oriented educational approaches are frequent, from the nursery school level (Czechoslovakia) through elementary and secondary teacher education coursework (Bulgaria, France, Norway and Sweden).

Varying degrees of integration of environmental studies with other subjects and interdisciplinary methodological approaches may be found. Most teacher education colleges in Norway offer integrated science courses, as do many programmes in the United Kingdom.

Some programmes contain specific courses in environmental education methodologies: the Royal Danish College of Environmental Studies in Denmark, many colleges in the United Kingdom, and some schools in Czechoslovakia are examples.

While it is recognized that environmental education lends itself to team-teaching methods, it has also been pointed out that a lack of interdisciplinary teacher co-operation is a major constraint in present environmental education efforts. The Swedish curriculum for the comprehensive school includes collective teaching as an important component. The integration of disciplines often depends on the lecturer's ability to relate subject matter through co-operative teaching approaches.

Most countries in the Europe region have identified in-service teacher education as essential for effective environmental education. However, relatively few efforts have been made to initiate programmes that supplement the traditional training of practising teachers.

Currently, the primary focus of environmental education in the affective domain is the development of attitudes that foster positive environmental behaviour. Since 1973, much of Iceland's in-service teacher training in biological and ecological education has been aimed at the adoption of, and training in, new methods and attitudes. The Norwegian Environment Project, a curriculum unit for grades 1-6, is oriented in part toward the development of attitudes, and provides teachers with specific objectives within this area. Czechoslovakia has oriented its in-service programme toward developing an interest in environmental care and has recognized that the affective component of teacher training is a teacher's self-education. The United Kingdom has stated that valuing is one of the methodologies that teachers need to be aware of, and Canada's Simon Fraser University in British Columbia offers a summer institute in environmental education for pre-service and in-service teachers that focuses, among other concerns, on envi-

ronmental ethics and lifestyles. In recent years, the institute has been moving more toward educating teachers to deal with values.

One of the principal elements of in-service teacher education consists of teaching new developments in ecological, economic, policy and human ecosystem fundamentals. Czechoslovakia and the Netherlands have recognized the need for building a strong cognitive background in ecological and environmental principles. Bulgaria, Finland and Norway all offer course or provide materials for teachers that are oriented toward increasing knowledge about environmental concepts. In the United Kingdom, the Council for Environmental Education has noted a lack of opportunity for training in wider aspects of environmental education, beyond the cognitive knowledge of environmental studies.

The Norwegian Environment Project has provided first to sixth grade teachers in the Nordic region with an environmental education, programme that is oriented in part to the development of process skills. The Project provides detailed guidelines for assisting practising teachers in using the activities so as to develop the student's background in this area most effectively.

The Netherlands recognizes a need for increased knowledge and skills of teachers and recommends a national training centre for environmental education to aid in meeting this need. The Biology Teachers Association of the Netherlands offers week-end exercises for teachers aimed at developing problem-solving skills with differing degrees of external control.

The International Microteaching Research Unit at Lancaster University (United Kingdom) offers opportunities for teachers to focus in part on practice in specific skills with the intention of preparing them to deal with different methods of class organization. Canada's Summer Institute in Environmental Education (Simon Fraser University) also focuses on skill development in teachers attending its workshop.

Most countries refer to deficiencies in teacher-training programmes, finding the majority of them to be theoretical and abstract. Programmes appear to be insufficient with regard to incorporating modern methods suitable for environmental education, including problem solving, practical experience and active participation of teachers and students in the learning process.

There have been significant efforts throughout Europe and North America toward educating teachers in various environmental education methodologies.

The Nordic countries have also taken some steps in this direction, mainly through the provision of education materials and workshops that employ a variety of methods (Finland, Norway). The Biology Teachers Association of the Netherlands offers week-end exercises in environmental education that provide first-hand experience with field methods and problem-solving approaches.

Czechoslovakia has recognized that furthering the education of practising teachers must include methodical aspects and the Federal Republic of Germany has noted that most of its programmes deal only with environmental problems and have built in methodologies for handling the affective components of environmental education. The United Kingdom recognizes that teachers need to be aware of such methodologies as direct learning, first-hand materials, field studies, discovery and valuing, and supplements its urban and rural studies with field work toward this end. The United States has developed at least one model for training upper primary teachers in multiprocess and multidisciplinary approaches to environmental education.

Two areas of methodology appear to have gained considerable attention throughout the Europe, region, namely the integration of environmental education into existing disciplines (environmental education as an interdisciplinary topic) and direct-learning approaches. The Helsinki Regional Meeting recognized the importance of direct involvement of teachers in interdisciplinary investigations and discussions on the content and methods of environmental education. Some countries (Sweden and the United Kingdom) have made special note of this need, while others (Canada, Czechoslovakia, the Federal Republic of Germany and the Netherlands) have initiated programmes that focus on helping teachers with interdisciplinary aspects of environmental education.

With regard to direct-learning approaches, Finland and Sweden have initiated summer field courses, especially on laboratory methods, and the Netherlands has instituted a support group between the Institute for Nature Conservation, school biology services, school advisory services, zoos, museums, botanical gardens, nature societies, etc. to help teachers without prior training in interdisciplinary projects. Since 1973, in-service education in Iceland has shown a trend toward more environmental education dealing with the school site and the community. Bulgaria offers courses for teachers on environmental problems that include excursions into the field, and the community, and Italy suggests teacher workshops using prospective Mediterranean multipurpose coastal parks as sites to illustrate direct-learning concepts.

There are several approaches to the implementation of programmes to train practising teachers in environmental education methods and concepts. Face-to-face programmes, such as workshops and teacher centres, have been especially successful in recent years in the Netherlands, Poland, Sweden, the USSR, the United Kingdom and the United States. Programmes via the mass media have been employed in the United Kingdom and the United States, and clearinghouses for information and materials exist in Canada, the United Kingdom and the United States. The Regional Meeting of Experts on Environmental Education in Europe, Helsinki, 1977 (hereafter referred to as the Helsinki Meeting) endorsed the need for lifelong teacher education and recommended that 'in-service training... be established by co-ordinating the work of educational authorities, environmental authorities and the educational sectors of the mass media.'

The Nordic countries are among the most active in establishing in-service programmes. Model courses have been held for instructors from all five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), who then return to their home countries to offer the same programme to local teachers. The Norwegian Environmental Project includes curriculum units and instruction handbooks for first to sixth grade teachers throughout the Nordic region. Norway also touches on environmental education in a number of its existing in-service courses.

Swedish National Board of Education's Commission on Environmental Training at School has prepared manuals for teachers. A week's seminar on the environment dealt with Environmental Teaching Aids; Environmental Laboratory Exercises and Excursions; and Environmental Training on Technical and Economic Lines at the Upper Secondary Level. Sweden also recommends that every school have an environmental education co-ordinator.

The Netherlands has found that many of their in-service programmes fail in practicality and active participation. Czechoslovakia also sees the training of instructors as a major problem and

offers special seminars and courses on the relationship of people to their environment to overcome this problem.

Each administrative region in the USSR has an institute for in-service and pre-service teacher training. All secondary teachers are obliged to attend the institute once a year to receive some nature conservation instructions. Malta offers one in-service course for science teachers in government schools. Many in-service programmes are being implemented throughout the United Kingdom. Day and evening courses, many of them for university credits, are arranged by directors of teacher centres, and some universities offer special environmental education degree programmes for practising teachers.

The United States has recognized the need for various organizations to offer workshops and conferences for teachers. These organizations include unions, professional organizations, school district administrators, teachers and curriculum developers. Canada has taken little action in implementing programmes and has noted a lack of teacher interest in environmental education and a lack of trained teachers to implement such programmes.

Much attention has been paid to the need to co-operate regionally and internationally in programmes aimed at preparing in-service teachers. Czechoslovakia has encouraged co-operation between specialists in environmental care problems in teams or in international cooperatives to ensure adequate information for teachers. The United States has established the Educational Resources Information Centre (ERIC) system which provides an international clearinghouse on environmental education materials readily available to teachers.

The Nordic countries exhibit the strongest international co-operation system: materials and prepared courses are offered jointly by the five Nordic countries for the purpose of sharing information and expertise. Model courses are held for instructors who are then trained to provide similar courses in their own countries, establishing a growing network of in-service training. Study units and instructional handbooks have been prepared expressly to form a coherent scheme of teaching materials in the five countries. The Nordic Co-operation Programme is administered by the Secretariat for Nordic Cultural Co-operation.

Teacher training in environmental education in the socialist countries of Europe stresses social and political considerations linked to, and stemming from, a particular productive system and form of society. Environmental education concepts, goals and tasks are introduced early, followed by scientific content and practical work. Socially useful work is a component of teacher training, developing the necessary knowledge and skills for the future direction of school children, in such activities as tree planting, flower shows, care of forest and fish reserves and nature protection in general. Instruction includes the fundamentals of ecology in the sciences, chemistry and geography faculties (elective in other faculties) and the forms include lectures, seminars and field work. All teacher-training institutions and faculties have a special course on the protection and conservation of nature.

In Bulgaria, for instance, the Faculty of Chemistry and Biology of Plovdiv University offers a course on general ecology, which ranges from principles and concepts to the biological basis for the protection of the natural environment. In Czechoslovakia, the Pedagogical Faculty of Gradts-Karlov University presents a course entitled 'Environment' which deals with biogeography, dynamic balance in nature, the impact of human activity on the natural envi-

ronment and what can be done about it. In the German Democratic Republic, the Pedagogical Institute's course emphasizes ecology, socialist use of nature and environmental protection.

In Poland, the University's Biology Faculty has a course which treats demography, industrialization and urbanism as well as water, air, soil, flora and fauna, etc. In the USSR, pedagogical institutes offer an overall course on the protection of nature with both a historical and basic science content. In Yugoslavia, teacher-training colleges offer a general course on nature protection as well as specialized courses for science teachers.

The environmental education of in-service training of teachers is being developed and conducted in a variety of ways, as may be seen from the examples which follow. In Bulgaria, an in-service teachers' institute holds a 10-day course for teachers and specialists on environmental conservation with lectures, classroom and field work. In Czechoslovakia, a similar institute includes an environmental education component in all retraining programmes, which individuals undergo every five years. The German Democratic Republic offers a 10-day series of lectures and practical work.

In Hungary, the essentials of environmental education are part of teacher retraining conducted by the Pedagogical Institute. In the USSR, teacher retraining through short courses takes place regularly at an advanced teacher-training institute. A full two-year course is conducted as a programme of the people's universities. In Yugoslavia, there are centres for in-service training of teachers at the district, regional and federal levels. Courses take the form of seminars.

The problem of co-ordinating pre-service and in-service training of teachers is generally recognized as well as the work still to be done in order to train an adequate number of qualified teacher trainers in the field of environmental education.

The following survey of environmental education training of teachers in the Latin American and Caribbean countries is based on existing material. Specific information about teacher training in environmental education is relatively rare, however, and conclusions must be tentative and partial.

First, most environmental education programmes in the region, with a few exceptions, are based on a restricted concept of environmental education, that is its conservational and ecological aspects: the man-made environment and such social aspects as overcrowding and poor sanitary conditions receive scant attention. As a consequence, the teacher training undertaken by these programmes is directed more toward conservation and protection of the natural environment than toward finding ways to improve the human environment in an integrated manner. Second, teacher-training activities seem generally to be a secondary preoccupation in the environmental education programmes examined, as if they were incidental. Nevertheless, in each of the cases below an effort has been made to bring out explicit teacher-training components or to reveal implicit ones as much as possible.

In Argentina, the Study Centre for Atmospheric Contamination, Santa Fé, has been conducting teacher-training activities since 1974, particularly in the use of measuring instruments and interpretation of the resulting data. A seminar was held in Cordoba in 1975 for teachers at various levels to examine and develop higher education curricula and courses on the conservation of renewable natural resources. A special course for teachers on population, ecology and the family was organized by Cordoba University in 1972. The Educational Research Centre of Buenos

Aires has designed and tested a method for training educators in workshops.

The Centre for Educational Research and Action of Bolivia is undertaking a programme of community education aimed at improving the quality of life in marginal rural and urban areas. The programme centres on local schools: teachers and monitors previously attend specially designed training courses.

In Brazil, the municipality and the State University of Campinas are carrying out a city project for the development of educational activities promoting community improvement of the human environment.

The project is conducted by University graduates with the help of local authorities and graduates of the Faculty of Education who receive practical training in the field. The resettlement of the marginal population around Brasilia in Ceilandia has involed an integrated environmental education programme for the improvement of living and social conditions. The project, centred on the school, aims at community participation in a broad educational process. Teachers have been trained in courses and seminars to promote the process. A national environmental education training seminar in 1979 developed a teaching module and guide for environmental education instructors. A course for training primary teachers in ecology, complete with self-instruction guides, has also been developed nationally.

In Colombia, three successive seminars have been organized on the teaching of ecology by the Institute for the Advancement of Higher Education. The first experimental workshop in environmental education, centred on the Saldana River basin, was held in 1977. Teachers, student teachers and teacher trainers were among the participants; various training instruments were developed. The Education Ministry co-operates with INDERENA in organizing training seminars for environmental education personnel inside and outside the school. The Ministry also co-operates with the National Coffee Industry Federation in experiments for transforming rural primary schools into community education centres for local environmental improvement. Emphasis is placed on the training of teachers.

The National University of Costa Rica offers formal environmental education courses for teachers, a bachelor's degree in teaching environmental sciences training for primary teachers and seminars on various environmental education themes.

In Cuba, a national environmental education seminar was held in Havana in 1979 with the participation of normal school teachers and administrators and officials of the Education Ministry.

The Education Ministry of Guatemala initiated a project in 1977 for incorporating the environmental dimension into early primary school education and organized four meetings to prepare 240 teachers and school administrators.

In Mexico, the objective of an agreement between the Ciudad Juárez University and Texas University (the United States) included the environmental education training and exchange of teachers. In Panama, in-service training of teachers has been developed for an experimental project incorporating environmental education into primary school education.

Teachers have been trained in Peru for an environmental education project involving secondary schools of Lima as well as general community health education. Training teachers in community development is considered basic to Peru's educational reforms.

In Venezuela, an environmental education pilot project, conducted by the Experimental Institute for Teacher Training, aims at introducing environmental education units into the third year of secondary schools. The Central

University has added an environmental education component to a Latin American manual for basic education teachers. The National Centre for Improving the Teaching of Science has developed ecological materials for secondary school teachers.

In the Bermudas, the Caribbean Conservation Association has organized environmental education courses for teachers and prepared audiovisual materials for their use. In the Dominican Republic, the National Park Service has held an environmental education seminar for normal, secondary and intermediate school teachers. In the Turks and Caicos Islands, the Society for the Protection of Reefs and Islands has organized environmental education courses for government officials, school teachers and others. In Jamaica, environmental education workshops have been set up for primary and secondary school teachers.

A preliminary to many of these activities was the subregional environmental education training workshop for the Caribbean organized by UNESCO and held in Antigua, 9-20 June, 1980 (see **Connect**, September 1980).

In summary, since 1977, the countries have done a great deal to improve the training in environmental matters of teaching personnel at all levels of school and out-of-school education; they consider that such training is a key factor in the development of environmental education at national level. New courses on the environment for school and out-of-school education cannot be introduced, nor can educational material be properly used, unless teachers are given suitable training as regards both the content of environmental education and the methods that should be used. Moreover, teacher training plays a strategic role in that, it is the best way of multiplying the impact of environmental education at national level, thereby increasing the effectiveness and the cost-effectiveness of the efforts made by states for the development of environmental education.

The development of school and out-of-school environmental education is to a large extent conditioned by the progress (or shortcomings) of teacher-training at a given moment. Thus the trends noted in the previous chapter can be explained, in the main, by the strategy which countries have adopted in the area of training.

As for the pre-service training of school teachers, environment-linked subject-matter has usually been incorporated into the natural sciences (biology, chemistry, physics). For some time now, it has been 'infused' into some social sciences subjects (especially geography).

The initial environmental training provided for teachers is still, in most cases, restricted to certain disciplines, and to a large extent the conception and development of interdisciplinary approaches meet with the same obstacles that are encountered in schools as regards subject-matter and teaching methods in environmental education. Moreover, this training is too often sporadic and theoretical in nature, and is restricted to certain environmental problems (in particular the conservation of natural resources). Some Europe region countries have, however, succeeded in working out courses providing more thorough pre-service environmental training.

An increasing number of countries in all regions of the world have made available in-service environmental courses for teachers, often in co-operation with UNESCO, including classes, seminars or workshops, pilot projects, practical courses, etc. In-service training is the only means of giving teachers a systematic training in environmental matters while they are working; being less subject to the rigidity of single-discipline teaching and the institutional

constraints which characterize initial training, in-service training is more suitable for dealing with environmental situations from trying out active teaching methods in the domain of environment. Nevertheless, in-service training poses numerous problems — problems of a temporal nature (what is the best time to organize it: in school time or during the holidays?); and problems of a financial nature — for some countries consider that it would be very costly to provide lengthy in-service training. All this explains why most courses are organized for a few days, from time to time, and for a small number of teachers. Moreover, those taking the courses do not appear to be highly motivated since they see it as unpaid work.

Given the importance of in-service training these considerations should incite those responsible to work out and develop strategies of in-service training that are more worth while for both the individual and the community.

In the past few years, the provision of environmental training for teaching personnel has not developed uniformly throughout the school system. Primary school teachers, for instance, seem to have received a more thorough training in environmental matters than secondary-school teachers. This is probably due to the fact that the training of primary school teachers, since they have to teach a wide range of subjects, favours the treatment of the complex subject-matter and various methodological approaches of environmental education, whereas the training of secondary school teachers remains essentially specialized in specific subjects. The priority given to the training of primary school teachers is also confirmed, from the quantitative point of view, by the fact that most Europe region countries, as well as a few countries in other regions, have introduced an initial training course, both theoretical and practical, for primary school teachers.

Generally speaking, the personnel engaged in out-of-school educational activities (industrial and agricultural instructors, etc.) receive little training in environmental matters, and the institutions responsible for their training have no concerted policy on the matter; such personnel, of course, does not really come within the competence of ministries for education. The training of certain categories of educators, however, seems to have received special attention in some regions. For instance, in most Latin American countries the training of agricultural instructors has been developed thanks to the endeavours of the public sector, and also to the influence of the multimedia training system set up by the national committees of the Association Latinoamericana de Education Radiotónica (ALER). Experiences of a similar nature have been carried out in Africa and Asia (particularly in India, the Ivory Coast, Kenya and Senegal) and programmes have been designed to train educators of adults in the framework of functional literacy programmes (especially in the Congo, Mali, Nepal, Thailand, the United Republic of Tanzania, and the Upper Volta).

Despite the progress achieved in teacher training and the undeniable importance of some experiments, there is still a considerable need in all regions in regard, more especially, to the training of secondary school teachers and of those responsible for out-of-school educational and training activities.

FORMS AND METHODS OF ENVIRONMENTAL EDUCATION

Unified Approach to the Teaching of Environmental Sciences

A unified approach to the teaching of the environmental sciences is a guiding principle in the field of environmental education. The content of this principle is reflected in the materials of the Tbilisi Conference and summarized in the following major provisions.

Environmental education is an integral part of the education process. It should be centred on practical problems and be of an interdisciplinary character.

Within the framework of formal education all elements of the education process should be taken into account (curricula and programmes, works of literature and textbooks, teaching aids, methods, etc.) and gradually reach interdisciplinarity. Without denying the existence and individuality of each classical discipline, it is necessary to avoid an excessively analytical character in the disciplines and allow for differences connected with their methods, since these make it difficult for the students to perceive the environment as a whole. An approach based on consistent abstraction leads pupils away from proper study of the environment. In this connection the following solutions are possible: to integrate into each discipline necessary aspects of environmental problems; to develop educational programmes by interdisciplinary teams; and to study concrete environmental problems.

Environmental education should not be just one more subject to add to existing programmes, but should be incorporated into programmes intended for all learners, irrespective of their age. Environmental education should play the role of a catalyst, or common denominator, in the renovated process of modern instruction. It is necessary to establish and uphold clear and functional ties between requirements, goals, tasks, the programme itself and evaluation methods.

Special preference should be given to various social groups who find themselves in less favourable conditions in many countries, for instance, illiterate people. Therefore it is necessary to find for them ways of education by means of providing functional literacy, including aspects of the environment (at the beginning, aspects of their social, and later professional milieu).

Environmental education should not be a matter of 'competition' with various disciplines which are at present included in the educational plan; it should be a means for promoting the recognition by pupils of a certain unity of the educational process and make it possible for them to develop the knowledge, skills and attitudes for preserving and improving their environment.

Certain environmental problems are not related to the sphere of direct youth experience, and even for experienced students the understanding of environmental problems demands conceptualization, the ability to expound things on the basis of comparatively abstract symbols. The primary rule is to accord the means of education with the intellectual and physical stage of the recipient (learner) and in accord with all other important pedagogical laws, specially with the specific principles of environmental education. Secondary schools should concentrate on the ecological, social, political and economic aspects of environmental education.

In non-formal or out-of-school education, the strategy of supporting and developing environmental education depends on specific conditions (for instance, rural or urban environments). It

should be based on the means of social communication, mass media, on various movements or associations [129].

Programmes Oriented to Environmental Problems (examples)

The interdisciplinary aspect of environmental education predetermines the teacher's development of such education programmes of nationally adapted courses to ensure the necessary minimum environmental education for pupils. Regardless of regional aspects of education and forms of teaching, these programmes should include a compulsory set of topics and questions which would be gradually expounded during the study of particular disciplines, taking into account the term of study and age of the pupil. The basis of a tentative programme can be found in the following project:

Topic 1: **Purpose and role of the biosphere.** Energy flow and its forms. Biological cycle of substances. The formation of the biosphere, its structure, borders and evolution. Origin of life on the Earth. Geographical structure of the biosphere. Ecosystems and their biological efficiency. National features of ecosystems and the noosphere.

Topic 2: **The environment and its elements.** Nature and natural resources. World nature resources. Classification of natural resources. Renewable, partially renewable, non-renewable natural resources. Exhaustible natural resources. Inexhaustible natural resources.

Topic 3: **Reserve of natural resources.** Land resources. World Ocean resources. Role of the World Ocean in developing the economy and satisfying the population's needs for foodstuffs. Main factors hindering the use of World Ocean resources. Sources of World Ocean pollution. Protection and exploitation of seas and oceans. National characteristic features in exploiting World Ocean resources. International activity for the protection of the World Ocean from pollution. Mineral resources and their significance for the development of industry. Land resources. Vegetation resources.

Topic 4: **Man and ecological balance.** Social production and living standards. Technological process and its role in environmental protection. Armaments race and the irrational exploitation of natural resources. Environmental pollution control.

Topic 5: **Atmospheric exploitation.** Composition of the atmosphere. Atmospheric pollution and its sources. Atmospheric pollution consequences. Losses from atmospheric pollution. Standardization of atmospheric air and pollution control measures. Characteristic national features of atmospheric exploitation. International activity for protecting the atmosphere from pollution.

Topic 6: **Conservation and exploitation of water resources.** Water and its significance for life on the Earth. Freshwater resources. Shortage of water resources. Regional and interregional aspects of water use. Structure of water use and tendencies toward its alteration. Water resources conservation measures. Water conservation means. Characteristic national features of water resource use. International activity for water resource pollution control.

Topic 7: **Conservation and exploitation of land resources.** Land resources and their structure. Role of land resources in solving the food problem. Green revolution. Factors influencing land resource exploitation. Raising land fertility. Agricultural production. Water and wind erosion. Drainage of swampy lands. Recultivation, soil conservation and soil depletion control. Land resource pollution control. Characteristic national features of land resource exploitation. Desertification and its control.

Topic 8: **Conservation and exploitation of biological resources.** Exploitation and reproduction of forest resources. Pest and disease control in forests. Human impact on the quantity and quality of animals. Conservation of flora and fauna. Red Data Books. Characteristic national features of biological resource exploitation.

Topic 9: **Population problem.** Population dynamics. Major reasons for population growth. Urbanization. Development of cities and environmental protection. Environmental protection and the development of tourism. Characteristic national features of the demographical situation.

Topic 10: **The environment, public health care and the food problem.** Interrelation between the state of the environment, food problems and public health. Effects of environmental pollution on the health of the population. Major reasons hindering foodstuff production. The preventive role of public health bodies in the struggle against environmental pollution, hunger and malnutrition.

Topic 11: **Environment and economic development.** Socio-economic development factors. The role of natural resources in ensuring social and economic interests. Interrelation between the state of the environment and economic development. Conservation and rational use of natural resources as a prerequisite for development. The concept of a new international economic order. Internationalization of a new economic order.

Topic 12: **Environmental management control.** Planning of environmental management. Environmental control. Monitoring. Environmental information. Government bodies responsible for national policy in the field of environmental management. Financing of environmental management measures. Ecological and economic production efficiency. Characteristic features of environmental management in industrialized countries. Policies of developing countries in environmental management. Characteristic national features of environmental management control.

Topic 13: **International co-operation and environmental protection.** International goals and tasks of environmental protection. International environmental legislation. Bilateral and multilateral co-operation for the conservation and rational use of natural resources. National aspects of bilateral and multilateral relations in environmental protection.

To some extent the proposed topics and basic questions can serve as a reference for school instruction on major interdisciplinary questions of environmental education in the following subjects: history, geography, natural sciences, biology, physics, chemistry, literature, arts, hygiene, international affairs, health and nourishment, social sciences, civic and moral upbringing, etc.

Forms of Education

For primary and secondary education, interdisciplinary aspects of teaching environmental education are based on historically shaped national systems of education and those requirements which stem from the peculiarities of the social, economic and political development of the particular country and region.

Developing countries, among many other 'heredity vices' of colonialism and neocolonialism, suffered from mass illiteracy.

At the beginning of the 1960s, adult illiteracy in Africa reached 81 per cent (124 million persons), in Asia — 55.2 per cent (542 million persons), in Latin America — 32.5 per cent (40 million persons). In 1960 less than one quarter (24 per cent) of children and youth in Africa from 5 to 19 years of

age were involved in any educational system, the number of secondary school students was only 10 per cent of the total enrolled in primary and secondary schools (19 per cent in developing countries of Asia and 12.4 per cent in Latin America) [17].

Because the economy and culture of developing countries to a great extent depended on the policies of the colonizing powers, the dominant place was taken by British, French and Spanish systems of education. Regardless of the adoption of regional programmes for fighting illiteracy, such as the 'Karachi Plan' for the Asian countries, the 'Addis Ababa Plan' for the African countries, and the 'Santiago Plan' for the countries of Latin America, which became an important landmark in the development of world culture, the systems of education which functioned in developing countries more than 20 years ago, though somewhat modernized, have retained their leading positions. The major forms of school education in these countries are primary, incomplete secondary, and secondary, conducted at schools of various types and classes, including public and primary schools, incomplete secondary and secondary schools, secondary education in grammar, commercial, comprehensive and modern schools, as well as general education **lycées** and colleges with different terms of study. Most of these schools teach reading and writing and elementary subjects and for this reason it is very important to arrange the time table so as to foster in children a love for their native land and for nature without harm to the main subject, and a sound attitude to land, water, forest and other resources of the environment.

In subsequent stages of education, the minimum of basic knowledge received can be consolidated in history, geography, natural science, biology, physics, chemistry and other lessons, by correctly distributing the topics for each year of study. A careful analysis of curricula indicates that additional reserves of time can be found, as a rule, by eliminating duplication of subjects, as well as by a slight redistribution of lesson hours for particular disciplines.

Importance should be given to environmental education in technical and vocational education. In this connection, the Tbilisi Conference recommended the incorporation into curricula of technical and vocational education of information about the environment to ensure ecological knowledge. Vocational education so modified will promote increased awareness of the relationship between people and their social, physical and cultural environment, and foster a desire to improve the environment through influencing decision making processes [129]. At the same time it was stressed that special attention should be given to environmental impacts on workers in each vocation and to the collective effects of related vocations upon the environment.

In fulfilling this recommendation of the Tbilisi Conference, the USSR State Committee for Vocational Technical Education determined two major strategies for the country's environmental education: broad familiarization with different aspects of nature protection in the technical and vocational cycle, and general education subjects, stepping up practical training in nature protection for students of technical and vocational schools [13].

In accordance with these strategies, students of technical and vocational schools participate in the planning of villages and towns, and carry out useful work in environmental protection from pollution. Other forms of education in the environmental field include specialized secondary and higher education, as well as various systems of extending workers' and employees' qualifications.

Teaching Methods

Content and methods of teaching environmental education were set forth in recommendations of the Tbilisi Conference which considered:

that the separate disciplines which may bear on environmental issues are often taught in isolation from each other and may tend to neglect or pay insufficient attention to environmental problems;

that separate as well as interdisciplinary approaches both have important parts to play, depending on situations, learning groups and age levels;

that teaching methods for either type of approach are still in the process of development;

that the incorporation of environmental education into existing curricula or teaching programmes is often slow;

that the criteria on which to base the content of environmental education programmes and curricula are also in need of further development;

that socio-economic conditions determine different educational aspects;

that historic and cultural landscapes and situations also demand special consideration;

that particular sections of the community, such as farmers, rural inhabitants, managers, industrial workers and others, need specially adapted environmental education programmes;

that in most if not all programmes and curricula, the teaching of ecological concepts plays a fundamentally important role;

that environmental education should preferably be oriented towards the solution of problems (problem-solving approach) and be concerned with opportunities for action (action-oriented approach)... Research relevant to these different approaches, aspects and methods is needed to provide a sound basis for the development of environmental education curricula and programmes, so the Conference recommended:

that educational and training institutions should have the necessary flexibility to enable them to include appropriate aspects of environmental education within existing curricula and to create new environmental curricula that meet the requirements of an interdisciplinary approach and methodology;

that relevant authorities work out criteria on which to base the environmental content of the curricula to be offered to pupils and students according to individual needs and taking into account local, social, occupational and other factors:

that within the framework of individual systems, encouragement and support might be provided for subject disciplines to identify and give priority to their special contribution to environmental education; and for those responsible for the planning and carrying out of programmes of general and vocational education to encourage that through interdepartmental collaboration and co-ordination, environmental aims and objectives are adequately served;

that they examine the potential of appropriate institutions to carry out research into the development of curricula and programmes in environmental education and encourage necessary initiatives, including institutional co-operation;

that responsible authorities support curriculum development as it relates to particular situations such as exist in urban areas, rural areas and areas of social, historical and cultural importance, and to the needs of particular groups such as farmers, industrial workers and parents;

that in all approaches full and adequate emphasis is given to the teaching of ecological concepts, to the sys-

tems of the atmosphere, lithosphere, hydrosphere and biosphere and to relevant socio-economic aspects [129].

Flexibility and Variety of Teaching Methods

The flexibility and variety of teaching methods of education in the environmental field depend on the contingent of students, their age and form of instruction and on the professional skills of the teacher. From this point of view, environmental subjects differ from a number of other courses in that they involve problems of immediate concern to the student. Nature conservation themes should be integrated into all lessons gradually. The main goal here is to evoke the interest of children in each nature object and foster respect and sympathy for every living thing, because each organism is inimitable and a link in the chain of complicated natural relationships and interrelationships [18].

Nature and labour are the main sources of life and development on the Earth. That is why lessons should be supplemented by the participation of pupils in various practical environment protection activities.

The flexibility and variety of teaching methods also depend to a great extent on how the teacher motivates students with the very idea of environmental protection, what conceptions and categories he or she uses and what practical material is the basis of the instruction.

Of great importance is the teacher's personal conviction of the need to teach interdisciplinary environmental issues at all levels of formal and non-formal education.

Finally, it should be emphasized that the success of environmental education largely depends on a well-developed system of instruction and on consistency in the presentation of its various issues.

Chapter II

BASIC COMPONENTS OF ENVIRONMENTAL PROBLEMS

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FUNCTION AND ROLE OF THE BIOSPHERE

Flow of Energy

The biological unity of the environment consists of a continuous circulation of organic and inorganic matter. This circulation is a result of energy conversion whose basic property is an ability to perform a certain kind of work. In most organisms, this function is determined by diverse processes of their vital activity. According to Owen, animals need energy for food uptake and digestion, transformation of food into protoplasm, synthesis of hormones and enzymes, blood circulation, maintaining constant temperature of the body, and for respiration, excretion and movement. Plants need energy for photosynthesis, synthesis of growth substances and leaf pigments, formation of flowers and seeds. All organisms need energy for their growth and reproduction. Energy is not cyclic, it continually dissipates from ecosystems and therefore needs to be constantly replenished by solar energy [19].

The energy structure of the environment is formed under the effects of solar radiation and thermal radiation from nearby objects whose temperature is above zero. The effects of solar radiation on various ecosystems are different depending on the spectral composition, periodicity of lighting and rate of action. The biological effect of solar radiant energy structure is determined by ultra-violet and infra-red rays, and also by visible light (Fig. 2).

Exposure of organisms to ultra-violet rays with a wave-length less than 0.300 μm causes their death. The existence of all living things on the Earth is possible only because short-wave ultra-violet rays, after passing through the ozone layer of the atmosphere, reduce their chemical activity and, at a wave-length of 0.300 to 0.400 μm and in comparatively small doses, produce a positive effect on the development of plants, animals and human beings.

A major portion of solar energy absorbed by the Earth falls on visible light with a wave-length of 0.400 to 0.750 μm. The importance of this region of the solar radiation spectrum lies in the fact that most plants can accumulate solar energy and convert it into the energy of chemical bonds. This is a most complicated biochemical process of photosynthesis due to which organic substances are formed from inorganic ones, carbon dioxide is derived from the atmosphere, and oxygen is produced to fill the air. The total influx of solar energy onto the Earth is about $2.1 \cdot 10^{21}$ J/year. Approximately 4.61-$7.1 \cdot 10^{20}$ J/year represent the share of the oceans.

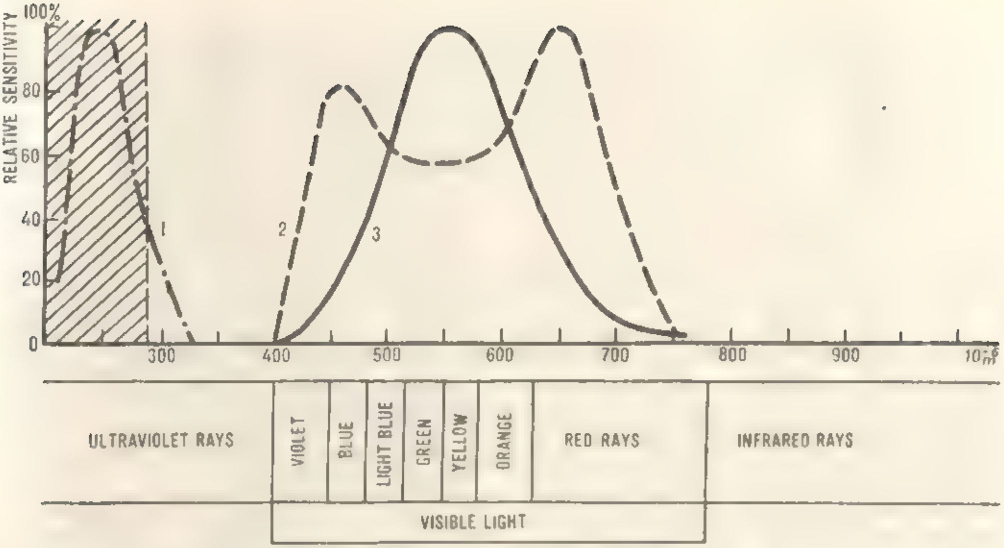

Fig 2 Biological effects of various regions of solar radiaton (according to Danilevsky, 1973)
1 — coagulation of protein; 2 — intensity of wheat photosynthesis; 3 — spectral sensitivity of human eye. Hatched is the region of ultra-violet radiation nonpenetrating through the atmosphere

Infra-red rays are an essential source of solar energy. They are not perceived by the human eye at a wavelength greater than 0.750 μm. Especially large amounts of infra-red rays are found in direct sunlight.

The second element of the environment energy structure is thermal radiation generated by plants, soil, clouds and other surfaces. Since solar radiation appears only in the day-time, the total amount of heat energy may considerably exceed that of solar radiation.

Additional Information

The properties of energy are described by the following laws. The first law of thermodynamics states that energy changes from one form to another but is not created anew and does not disappear. For example, light is one form of energy which can be turned into work or the potential energy of food, with the energy being conserved, not disappearing. The second law of thermodynamics is formulated in different ways, particularly as follows: processes associated with energy conversion can occur spontaneously providing energy changes from the concentrated to the dissipated form (e. g. the heat of a hot object spontaneously tends to dissipate in a cooler medium). The second law of thermodynamics can also be formulated in the following manner: since a certain portion of energy always dissipates in the form of heat energy which is inaccessible for use, the efficiency of spontaneous conversion of kinetic energy (e. g. light) into potential energy (e. g. chemical bonds of protoplasm) is always less than 100 per cent.

The most essential thermodynamic characteristic of organisms, ecosystems and of the biosphere as a whole is their ability to create and maintain a high degree of internal order, i. e. a state with low entropy (entropy is a measure of disorder or a quantity of energy inaccessible for use). A system pos-

sesses a low entropy if a continuous dissipation of easily usable energy takes place in it (e. g. energy of light or food) and its conversion into energy which is difficult to use (e. g. into heat energy). The ordering of an ecosystem, i. e. a complex structure of biomass, is maintained through respiration of the entire biocenosis, which pumps, as it were, disorder out of the biocenosis [19].

Like other stars of the Milky Way, the Sun is a huge rotating ball ($1.391 \cdot 10^9$ m in diameter) of brightly burning plasma whose density and temperature increase with depth. A nuclear reaction takes place in the depths of this blazing plasmoid within which temperature reaches 20 million degrees C, pressure — 1.5 GPa, and the density of substance exceeds the density of steel by a factor of 10.

The Sun is primarily (approximately 70 per cent) composed of hydrogen nuclei — protons which enter into the proton-proton reaction. This results in the formation of larger nuclei of helium and the release of colossal amounts of thermonuclear power. The Sun, a natural nuclear reactor removed from the Earth at a comparatively safe distance ($1.495 \cdot 10^{11}$ m, or about 107.4 to 107.5 Sun diameters) and having a mass of $1.99 \cdot 10^{30}$ kg, continuously transforms its own matter into energy ($1.26 \cdot 10^{34}$ J annually).

The Sun has its own cycle of motion: it completes one revolution about its axis in 27 days. The cycle influences life on the Earth since it determines the variation in intensity of different radiations. Solar cycles of longer duration were also registered: 22-year, 90-year, etc., but the main cycles (27-day and 11-year) are the most vital for the Earth's organisms [20].

All manifestations of life are accompanied by energy conversion, but in these processes energy is not created and not annihilated (first law of thermodynamics). The energy received by the Earth's surface in the form of light is balanced by the energy radiated from the Earth's surface in the form of invisible thermal radiation. The essence of life consists in a continuous sequence of such changes as growth, self-reproduction and synthesis of complex chemical compounds. Without energy transfer accompanying all these changes, there would be neither life nor ecological systems. We must not forget that our civilization is only one of the remarkable phenomena of nature, which are dependent on the continuous influx of concentrated energy in the form of luminious radiation.

Year after year solar radiation spreads into outer space. Some portion of this radiation falls on the Earth and, after passing through the atmospheric layers, streams onto forests, meadows, lakes, oceans, cultivated fields, greenhouses, glaciers and onto hundreds of other ecological systems covering our planet and making up part of its biosphere. When light is absorbed by an object and results in heating the latter, the light energy is converted into another form — heat energy, i. e. the energy of oscillatory and translational motions of molecules. Since the rays of the Sun are absorbed unevenly by land and water, there are warm and cold regions; this results in the formation of air streams which can rotate windmills and perform various other work, e. g. raise water by means of a pump against the pull of gravity. In this case, light energy is converted into the heat energy of the land surface, and then into the kinetic energy of moving air, which raises the water. The energy does not disappear in this process, but changes to potential energy since the energy latent in the raised water can be converted again into some other form of energy if the water is allowed to fall down into a well. The amount of energy available in some form is al-

ways proportional to the amount of energy in the converted form; therefore, knowing the amount of energy in one form, we can calculate the amount of energy in another.

As indicated by the second law of thermodynamics, any form of energy is turned, in the final analysis, into a heat form of energy, which is the least suitable for conversion into work and is most easily dissipated. Energy in any transformation tends to be converted into heat uniformly distributed among bodies which will thus have equal temperatures. Perhaps this tendency leads to the 'ageing' of the solar system. It is not quite clear so far whether this tendency towards energy levelling is characteristic of the entire universe.

At present the Earth is far from being in a state of energy balance. It has a great reserve of potential energy. The temperatures in various regions of the Earth are different, and these differences are maintained by the continuous influx of the Sun's radiant energy. Yet all the naturally occurring phenomena on the Earth which are known to us are associated with continuous energy conversion, being parts of the overall process leading to the stable energy balance. This can be compared with the efforts of a man rotating a treadmill: 'ascending' the steps on the wheel, he will never reach the top, but his efforts will lead to quite definite results: the wheel will rotate. Thus, on reaching the Earth, the Sun's radiant energy tends to change into heat energy. Only a fairly small portion of the light energy absorbed by green plants is transformed into the potential energy of food, the greater part being turned into heat which then leaves plants, ecosystem and biosphere. The rest of the living world derives the required potential chemical energy from organic substances created by photosynthesizing plants or chemosynthesizing microorganisms. For example, animals absorb the chemical potential energy of food and convert the larger proportion into heat, the lesser portion being turned into the chemical potential energy of protoplasm that is synthesized anew. At each stage of energy transfer from one organism to another a considerable part of the energy is converted into heat.

The second law of thermodynamics treating of dissipation of energy is linked with the principle of stability. According to this concept, any natural closed system with an energy flux passing through it — the Earth or some other small system, e. g., a lake — tends to develop towards a stable state and self-regulating mechanisms are generated. If such a system is exposed for a short time to some external effects, these mechanisms will ensure a return to a stable state. When the stable state is achieved, the energy transfer usually proceeds in one direction at a constant speed, which corresponds to the principles of stability [21].

Photosynthesis can be defined as 'a process in which the solar energy is used to convert carbon dioxide and water into sugar'. With a few minor exceptions, this process can take place only in the presence of chlorophyll, a green pigment, which performs the function of a catalyst in this reaction. The general equation of photosynthesis has the following form:

$$6CO_2 + 6H_2O + \text{solar energy} \rightarrow$$
$$\rightarrow C_6H_{12}O_6 + 6O_2 + \text{chemical energy}$$

The solar energy is 'trapped', in a sense, by chlorophyll and is fixed in a molecule of sugar in the form of chemical energy. The above equation is deceptive, since, according to it, carbon dioxide (CO_2) directly combines with water (H_2O) to form sugar ($C_6H_{12}O_6$).

In fact, this reaction has two main phases: in the first phase, in the process called photolysis, the solar energy is used to split up a molecule of water into hydrogen and oxygen, the latter gas being freed from plants as a by-

product. In the second phase, in the process called fixation of carbon dioxide, the latter combines with hydrogen to form sugar. Green plants annually fix 550 thousand million tons of carbon dioxide.

The above description of photosynthesis is an excessive simplification of an extremely complicated process including at least 25 individual phases, which is being intensively studied at the present time. Some part of the released oxygen can be directly used by plants or can diffuse from leaves through the smallest pores (stomata) into the atmosphere, where the released oxygen becomes accessible to other organisms. It has been calculated that if photosynthesis had suddenly ceased, the atmospheric reserves of oxygen would have been depleted in 2,000 years, at the end of which time all living creatures would certainly have died. Some ecologists are very much concerned about the fact that the progressive pollution of the sea medium with poisonous chemicals and industrial waste may ultimately reduce the photosynthetic activity of algae which now account for about 70 per cent of the entire photosynthesis on the Earth, thus causing the progressive reduction of oxygen content in the atmosphere. With the exception of a few simple organisms such as bacteria which secure energy for themselves at the expense of oxidation of inorganic compounds containing sulphur or iron, all living organisms are dependent on photosynthesis [19].

Biological Circulation of Substances

Under the action of solar energy a continuous process of circulation of various elements takes place in the biosphere. This process is called a cycle of substances in nature. There exist a geological (big) cycle and a biological (small) cycle which are closely linked with each other, constituting a single whole.

The geological cycle is characterized by an exchange of substances between the oceans and the land. The geological cycle performed by airflows carries over long distances an enormous amount of water and the particles contained in it. Within one minute 10^{12} kg of water evaporates from the Earth's surface. At the same time 2,248.32 J are consumed to form 10^{-3} kg of water vapour. Owing to circulation processes and water vapours, by means of which the air is continually warmed, an exceptionally powerful energy flux returns to the atmosphere.

But these are not the only distinctive features of the geological cycle of substances. It has a dual character of destruction and restoration. The destructive function of the geological cycle manifests itself in the effects of precipitation. Its water washes out organic substances and chemical elements and carries them away into the ocean, from the surface of which water evaporates for the subsequent destruction process. According to data assembled by the American scientists Lipman and Coniber, the loss of plant nutrition elements in the soil due to erosion is 20 times as high as the amount consumed by crops. According to Bennet [22], the soil in the United States annually loses 92 million tons of nitrogen, phosphorus, potassium and calcium through erosion. To compensate the amount of nutrients washed off every year from the fields in the United States, it would be necessary to spend $ 4 thousand million. According to rough estimates, in the USSR crop underproduction on eroded fields amounts to 90 million tons of grain per year [22].

The restoring function of the geological cycle results from the capacity of water to dissolve and leach mineral rock, turning the latter into nutrition sources accessible to plants.

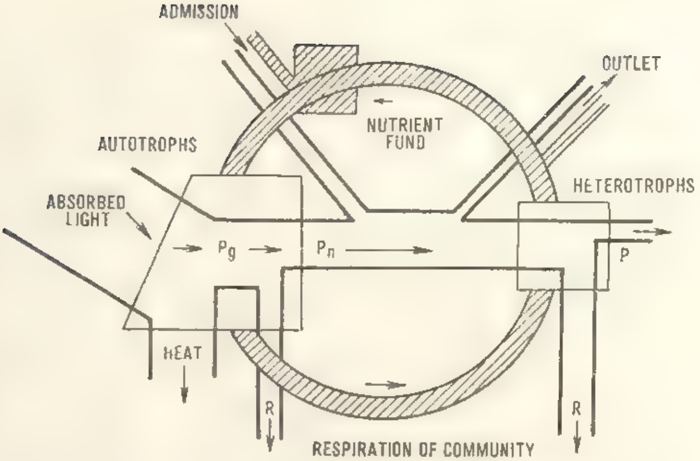

Fig. 3. Biogeochemical cycle (hatched ring) against a background of a simplified diagram of energy flux (according to Odum, 1975).

The biological cycle is the circulatory biogeochemical exchange of substances and elements between animate and inanimate components of the biosphere (soil, plants, microorganisms and the animal kingdom). This exchange is effected by means of undirectional energy fluxes (Fig. 3).

Odum emphasizes that elements in nature are almost never distributed uniformly throughout the entire ecosystem and cannot be found in one and the same form. For this reason, the reserve fund shown in Fig. 4 (i. e. part of the cycle of substances which are physically or chemically removed from organisms) is designated as the nutrient fund, while the exchange fund is represented by a hatched ring extended from autotrophic to heterotrophic organisms and from the latter again to autotrophic organisms [21].

In contrast to the geological, the biochemical exchange of substances and energy between the soil, plants, microorganisms and animals is a creative cycle, the basis of all living things on the Earth. Schematically, the biochemical cycle consists of three links:

first link: creation of organic substances by green plants through photosynthesis (primary production);

second link: conversion of vegetable production into animal production (secondary production);

third link: destruction of primary and secondary biological production by bacteria and fungi.

Three groups of organisms (Fig. 4) correspond to three links of the biological cycle.

The first group (producers) comprises autotrophic organism which produce organic substances from inorganic matter. These include mainly green plants, photosynthesizing solar energy. The flora of the Earth numbers approximately 500,000 species of plants of which 2,500 are involved in the plant growing activity of man. About 100 thousand million tons of organic matter are formed every year by photosynthesizing organisms. Simultaneously, the same amount of living matter is oxidized, changing to carbon dioxide and water as a result of the organisms' respiration.

The second group (consumers) comprises heterotrophic organisms existing at the expense of autotrophic ones. This group includes, in the main, animals which consume plants and the energy accumulated by the latter. In turn, three

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* Figs 4, 5, 8, 13-15 and 17 are in an inset.

orders of consumers are differentiated. Consumers of the first order are phytophagous animals, for example caterpillars and fishes; consumers of the second order are carnivorous animals which feed on plant-eating animals (predators) and parasites of plant-eating organisms; consumers of the third order include carnivorous animals living at the expense of other carnivores.

The third group of the biological cycle (reducers) comprises animals, fungi and microorganisms which feed on decomposing organisms of the first two groups. By destroying producers and consumers, microorganisms turn their organic remains into mineral salts, carbonic acid and water, thus completing one biological cycle of substances and starting a new one. Without microorganisms the natural self-regulation of the biosphere and reproduction of life would be impossible.

The scheme of the carbon cycle consists of three main links (Fig. 5):

first link: absorption by green plants through photosynthesis of atmospheric carbon contained in carbon dioxide. Part of the absorbed carbon in used to form organic matter. This process is accompanied by the liberation of oxygen. The other part returns again to the atmosphere in the process of respiration;

second link: utilization of organic matter by animals during feeding and partial return of carbon into the atmosphere during respiration;

third link: some part of the organic matter of plants gets into the soil, for example during defoliation, as does the organic matter decomposed by microorganisms while certain part of carbon returns again to the atmosphere.

As a result of the biological cycle of substances, a continuous process comprising the dying out of old and the formation of new plant and animal organisms takes place. Their volume is quantitatively expressed in terms of biomass. According to the findings of Duvigneaud and Tanghe [23] as much as $8.3 \cdot 10^{10}$ tons of organic matter is produced on the Earth by photosynthesis. Out of $5.3 \cdot 10^{10}$ tons produced on land, the share of forests accounts for $2.84 \cdot 10^{10}$ tons; the rest being synthesized by herbs and cultivated plants. The biomass of terrestrial animals, as a rule, is less than 1 per cent of the plant biomass, with invertebrates accounting for 90 to 95 per cent of the biomass of terrestrial animals. The ratio of the biomass of plants to the biomass of herbivores is as follows: in steppes and deserts — 10^2; in forest-steppes — 10^3, in tundra — 10^4, in taiga — 10^5. The ratio of the biomass of herbivores to the biomass of carnivores is always close to 10^2 [23].

Additional Information

Although students may be acquainted with elementary data on the organic kingdom and evolution and life development on the Earth, experience shows that their perception of new information, particularly on the biological cycles of substances, is rather complex. Hence, along with other instructional methods, teachers should pay attention to the simplicity of the subject, its axiomatic character. Of great importance is the use of examples, with illustrations supplied, to interpret the additional information on food chains, the biochemical cycle of substances in the biosphere as well as the biological cycles associated with oxygen, carbon, hydrogen, nitrogen, phosphorus and water cycles.

In a typical food chain terminating in a predator, for example wormwood-antelope-puma, a progressive decrease of the total biomass is observed at each succeeding trophic level conditioned by the second law of thermodynamics (Fig. 6).

If human beings were the only other link in the plankton-man food chain, they would have over 100 times more energy accessible to them than they get in the plankton-small aquatic animals-smelt-trout-man food chain [19].

The biosphere represents the unity of 'living' (i. e. as contained in organisms) and 'dead' (i. e. as found outside organisms) chemical elements involved in the sphere of life. Some 340 thousand million tons of various chemical elements are incorporated into life cycles by terrestrial plants. Sodium, potassium, calcium, manganese, iron, aluminium and many other elements are involved in the overall biological cycle. The content of these elements in the vegetation of the Earth increases from high latitudes to lower ones and from areas with excessive moisture to arid ones. The ocean plants contain a comparatively small amount of chemical elements — $36 \cdot 10^6$ tons, i. e. only 0.001 per cent of the amount contained in terrestrial plants.

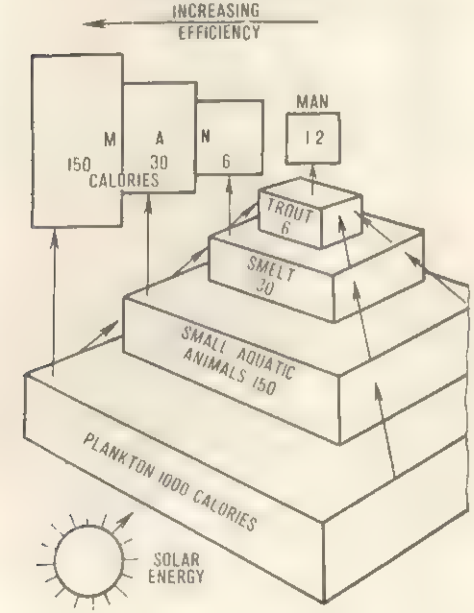


Fig. 6. Energy pyramid (according to Owen, 1977).

Table 1

Content of Mineral Substances in Phytomass of Various Geographical Zones

Geographical zones and regions	Amount of substance		
	average (kg/ha)	total (100 t)	average content in 100 g (%)
Frigid zone	142	115	0.8
Boreal	1761	4086	0.9
Subboreal	1113	2508	1.0
Including:			
humid	2244	1658	0.7
semiarid	735	596	3.5
arid	360	254	3.1
Subtropical	1836	4454	1.4
Including:			
humid	4148	2589	1.1
semiarid	1548	1283	1.6
arid	599	583	4.3
Tropical	4138	22 895	1.7
Including:			
humid	7188	19 051	1.6
semiarid	2189	3503	2.6
arid	266	341	3.3
Glaciers	0	0	0
Lakes, rivers	20	4	10.0
Land	2282	34 062	1.4
Ocean	1	36	0.1
Entire Earth	668	34 098	1.4

The amounts of mineral substances contained in the vegetation (phytomass) of different geographical zones are given in Table 1.

In oceans the state of the biosphere differs greatly from its state in continents. On land this state is dependent upon geographical latitudes, while in oceans this dependence is much less pronounced due to certain specific conditions of plant development in oceans and seas. Sunlight sufficient for photosynthesis, penetrates only to a depth of 100 metres, and in turbid coastal waters, to only 50—60 metres. For this reason, in the main mass of oceanic and sea water, primary (vegetative) biological production is practically not

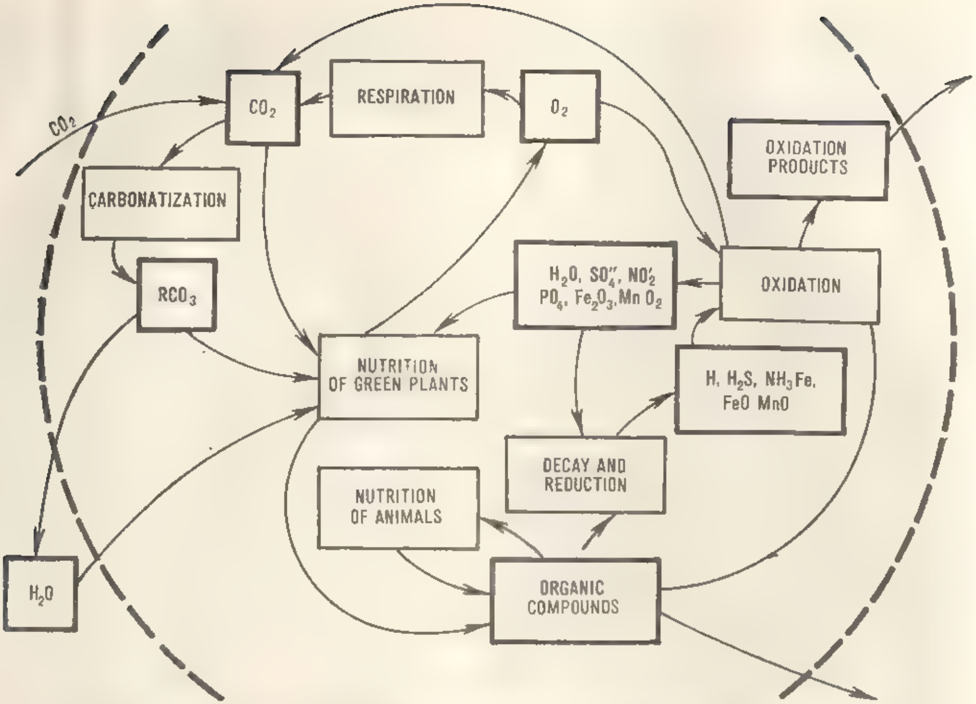


Fig. 7. Diagram of oxygen cycle (according to Smoliyaninov, Ryabukha, 1971).

formed. Here it only undergoes various transformations and decomposition.

Currents are an important factor in the formation of primary biological production in the ocean. They deliver to the surface layer those mineral elements required for the creation of living matter and provide specific thermal and gaseous conditions. As a result, in all geographical zones of the oceans there are areas alternatively rich and deficient in life. As a whole, the biomass of the ocean is 30 times as low as the biomass of the land [24].

The carbon content of the atmosphere is fairly low — only 0.03 per cent. As a result, the biological cycle of carbon is considerably more intensive than that of oxygen. It has been calculated that the carbon cycle rate is equal to 300 years, i. e. almost 7 times as high as that of oxygen cycle.

This carbon cycle, however, is somewhat complicated by the influence of the oceans. The same trophic (food) chain also exists in the ocean, including producers (phytoplankton), consumers (zooplankton, fishes, and other sea animals), and reducers (microorganisms). However, a certain part of the carbon of organic matter contained in the ocean remains in sedimentary rocks, such as limestones, etc., and is excluded from the cycle. Additionally, sea water contains dissolved carbon compounds, and deep-water layers, poor in oxygen, are richer in carbon than the surface layers. Currents mix deep and surface waters, thus causing circulation of the carbon dioxide dissolved in the sea water and in a continual exchange with atmospheric gas.

The diagram of the oxygen cycle, presented in Fig. 7, shows that oxygen

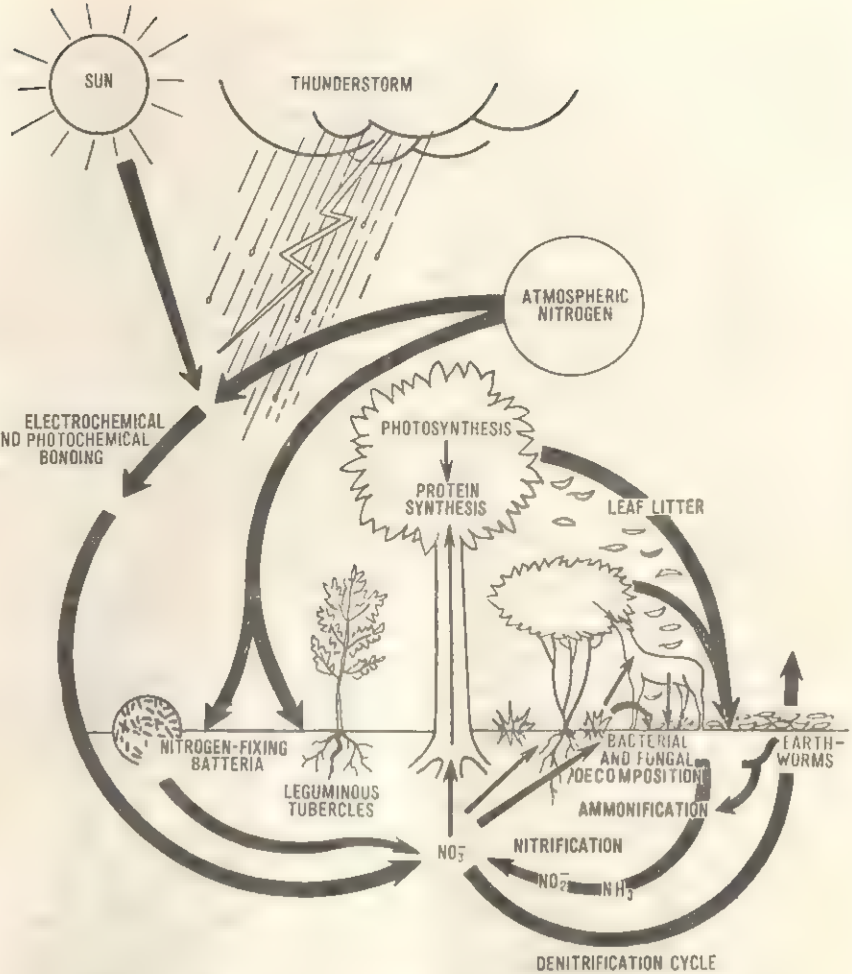


Fig. 9 Nitrogen cycle (according to Duvigneaud, Tanghe, 1973).

is mainly utilized by various organisms for respiration. Oxygen is also consumed for oxidizing processes of simple substances resulting from complex organic substances decomposed by microorganism. Much carbon monoxide gets into the atmosphere during volcanic eruptions. The carbon monoxide combines with the atmospheric oxygen to form carbon dioxide.

Photosynthesizing plants are the main source of atmospheric oxygen. In the process of photosynthesis they produce on land $53 \cdot 10^9$ tons of oxygen per year, and in oceans and seas — $414 \cdot 10^9$ tons.

At the present time the atmosphere contains about 21 per cent of oxygen, i. e. $2800,000 \cdot 10^9$ tons, which probably produced in the process of photosynthesis. It has been estimated that the total of atmospheric oxygen could have been formed during only 600 years and passes through all living matter over a period of 2,000 years.

Water cycle (Fig. 8) takes place in

a closed system. It includes evaporation from the ocean surface, evaporation from the land surface, precipitation in the form of rain, snow, hail and a certain amount of dew. Precipitation is distributed over the land surface in the following manner. A proportion of precipitation forms a river runoff and is used for domestic needs, industrial and public requirements, another proportion evaporates from crowns of trees and herbaceous plants, a third, without reaching the level of underground waters, is used by plants for transpiration, and a fourth, after seeping into underground waters, finds its way into hard crystalline and shale rocks, filling them with water.

At an average annual rate of atmospheric precipitation equal to 771 mm, less than half of this amount (367 mm) enters the sea with subsurface and surface runoffs (subsurface runoffs carry much less water than surface runoffs). A greater proportion of precipitation (404 mm) returns to the atmosphere. It should be particularly emphasized here that a substantial proportion of precipitation returns to the atmosphere through evaporation effected by the vegetation since plants absorb and evaporate some 38 per cent of the total amount of all precipitation. Despite a very great density of the population, the amount of water used for public utility services, for domestic and industrial purposes represents only 2.5 per cent of the total precipitation fund.

According to the estimates of Odum [21] the sea loses more water due to evaporation than it receives in the form of precipitation. The situation on land is quite dfferent. Thus, the part of precipitation which sustains terrestrial ecosystems, including those which supply foodstuffs for the population, is formed by sea evaporations.

Nitrogen cycle. Despite the fact that the atmosphere contains 80 per cent of nitrogen, plants absorb it in a limited quantity because they assimilate nitrogen only in the form of compounds with hydrogen and oxygen. A diagram of the nitrogen cycle is given in Fig. 9. The replenishment of the soil with bound nitrogen proceeds through several channels. One of the channels is related to bacterial decomposition of decaying plants and animal organisms, resulting in the incorporation of bound nitrogen into ammonia and ammonium salts (ammonification) which are subsequently oxidized to produce nitric acid (nitrification).

Another channel is nodule bacteria, generating tubercles on roots of leguminous plants (pea, bean, lupine) through which free atmospheric nitrogen passes into a bound state and then is assimilated by plants. The maximum amount of nitrogen is supplied to various ecosystem with the help of microorganisms — fixing bacteria. In addition, nitrogen gets into the soil with rain water due to lightning discharges. In the process of denitrification a certain amount of nitrogen passes to a free state and is lost.

Phosphorus cycle. The phosphorus cycle is of great importance for the life of animals and plants (Fig. 10). In contradistinction to nitrogen, phosphorus circulates in phosphorus-containing minerals involved in the composition of natural phosphates — apatites and phosphorites formed in earlier geological epochs. Phosphorus is accumulated in the plant-soil layer by means of phosphate-containing bacteria entering into the composition of various organisms. Much phosphorus is especially accumulated in bones and teeth of animals. Part of the phosphorus is carried away into the sea by surface and subsurface runoffs and settles in shallow and deep-water sediments, while the other part can be brought back to land in the form of guano (decomposition products of bird droppings). According to Odum [21], the transfer of phospho-

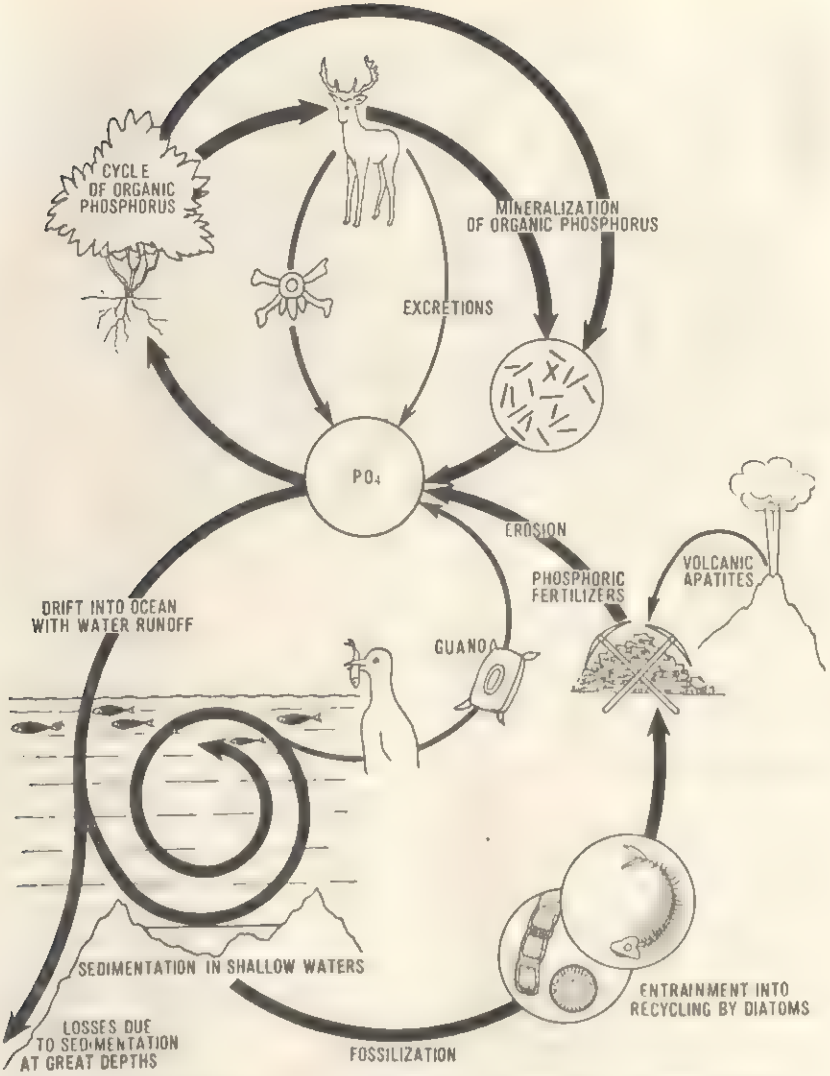


Fig. 10. Phosphorus cycle (according to Duvigneaud, Tanghe, 1973).

rus and other substances by birds is carried out now less intensively than in the past. In spite of the fact that 1 to 2 million tons of phosphorus-containing rocks are annually extracted on our planet, a greater part of it is washed out and excluded from the cycle, which, not without reason, is a source of apprehension to ecologists.

Formation of Biosphere, Its Stucture, Limits and Evolution

In 1809, the French naturalist, Lamarck in his work **The Philosophy of Zoology** expounded the basic principles of the evolutionary formation of the world, thus originating the dialectical-

materialist conception of biological science. Sixty-five years later, in 1875, the Austrian geologist Suess introduced a new notion — 'biosphere' — into scientific terminology, and several years later the German biologist Haeckel, a disciple and follower of Darwin, while studying the basic laws governing the evolution of animate nature, gave definition of the latter in accordance with the achievements of scientific thought at the end of the 19th century. However, advancement of the science dealing with the biosphere is mostly due to V. I. Vernadsky, who was the first to approach the problems of this science from geochemical and geological viewpoints.

The term 'biosphere' literally means the sphere of life, i. e. an envelope around the Earth inhabited by living organisms. But this is not the only distinctive feature of the biosphere. The other characteristic property of the biosphere is that the latter can be regarded as the lithosphere region occupied by transformers converting cosmic radiations into effective energy on earth — electrical, chemical, mechanical, thermal, etc. [25].

The basic element of the biosphere is living matter, i. e. the whole population of plants, animals, microorganisms and human beings. The Earth is inhabited by almost 2 million species of animals and plants, the latter accounting for 25 to 30 per cent of all species. The most widely distributed among animals are insects (750,000 species), then come mollusks (up to 100,000 species) followed by vertebrates (up to 70,000 species).

Due to the exceptional properties of living matter, the latter plays a planetary role in the formation of biosphere resources. Possessing tremendous energy, living matter influences the formation of soil, water, sedimentary rocks, and is involved in many other biospheric formations and transformations. Five functions of living matter may be listed [26]. With the help of the energy function, there occurs a process of solar energy absorption in photosynthesis, chemical energy is absorbed by the decomposition of energy-saturated substances, and energy is also transmitted through the food chain of heterogeneous living matter. The concentration function means the accumulation in the course of vital activity of definite types of substances, including those which are used for the building of an organism and are removed from it during metabolism. The destructive function of living matter manifests itself in the process of mineralization of non-biogenic organic substance; decomposition of nonliving inorganic matter; involvement of newly formed substances into the biological cycle. The environment-forming function of living matter lies in the conversion of the physicochemical parameters of the environment due to vital activity processes. The transport function means the substance transfer against the force of gravity and in a horizontal direction.

As a result of the migration of chemical elements during 350 million years, i. e. throughout the existence of the present amount of living matter, the biomass of $3.5 \cdot 10^{19}$ tons accumulated on the Earth, which is almost twice as much as the mass of the Earth's crust [27].

The formation of living matter, as well as of the entire biosphere, covers hundreds of millions of years and has passed through several evolutionary stages, hereditary variations, struggle for existence and natural selection. The historical development of higher plants is illustrated in Fig. 11.

Despite the absence of skeleton organization in fauna, which was a starting point for the construction of the stratigraphic scale of the Phanerozoic period, scientists discovered various remains of products of the vital activity of blue-green algae more than 2,500 mil-

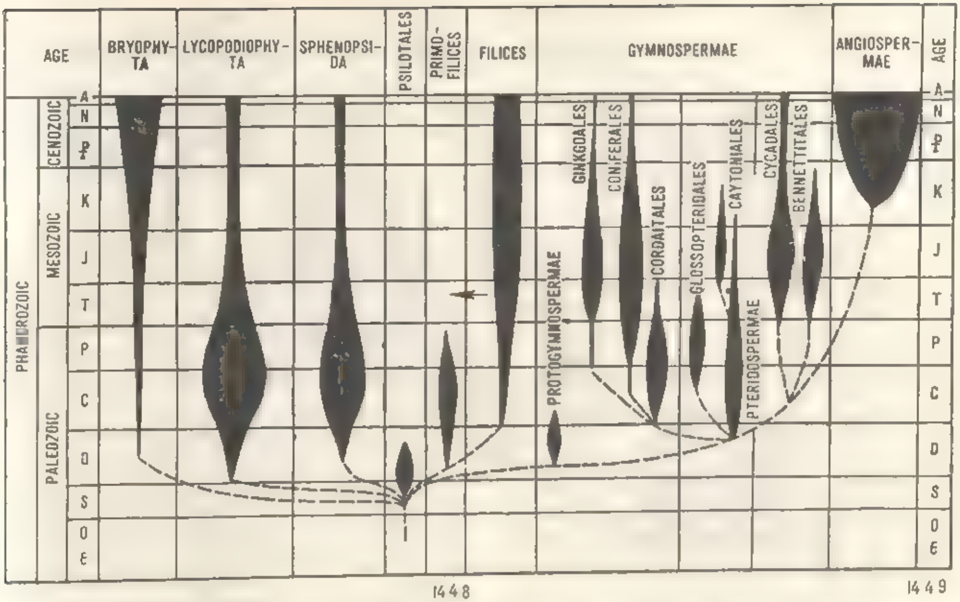


Fig 11. Diagram of historical development of higher plants (according to Drushits, Florensky, 1972):

Є — Cambrian period; *O* — Ordovician period; *S* — Silurian period; *D* — Devonian period; *C* — Carboniferous period; *P* — Permian period; *T* — Triassic period; *J* — Jurassic period; *K* — Cretaceous period; *P* — Paleogenic period; *N* — Neogenic period; *A* — Anthropogenic period.

lion years old, dating back to the Precambrian period (over 2,900 million years ago). The remains of animals relating to that period have been insufficiently studied but, according to the opinion of some specialists, they are of inorganic origin. The Ordovician period is represented by Psilotales which disappeared in the Devonian period, which was also the time when Sphenopsida, Bryophyta and Primofilices began to appear. The latter ceased to exist in the Permian period.

Caytoniales, which originated in the Jurassic period, disappeared from the face of the Earth in the Cretaceous period. Pteridospermae existed from the Devonian to the Cretaceous period. If Lycopsida, Sphenopsida and Primofilices are on the whole characteristic of the Paleozoic era, the Mesozoic era is represented by a wide range of renovated plant cover resulted from the appearance of Gymnospermae and Angiospermae.

The evolution of vertebrates is presented in Fig. 12. The first vertebrates appeared in the Ordovician period, represented by Agnatha ichthyoids with a two-chambered heart and the simplest cerebrum. During the transition to the continental region, most of these organisms died out and at the end of the Silurian period there appeared the first gnathic fishes. In the Devonian period there was an intensive development of Placodermi, Actinoptergii, Dipnoi and Crossopterygii. From these latter descended the first terrestrial quadrupeds — labyrinthodonts known as Amphibia.

The end of the Paleozoic and the beginning of the Mesozoic were characterized by considerable changes in the marine flora and fauna, which fact could not but cause changes in the spe-

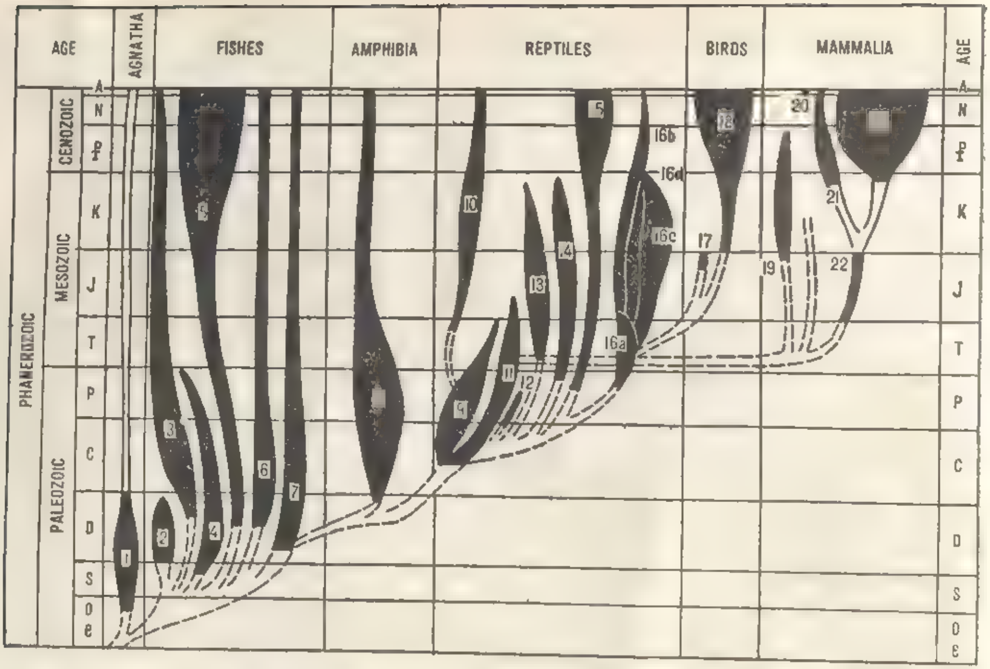


Fig. 12. Diagram of historical development of vertebrates (according to Drushits, Florencky, 1972):

1 — Agnatha; *2* — Placodermi; *3* — Chondricnthtyes; *4* — Acanthodii; *5* — Actinopterygii; *6* — Dipnoi; *7* — Crossopterygii; *8* — Amphibia, *9* — Cotylosauria, *10* — Testudines; *11* — Theromorpha, *12* — Proganosauria; *13* — Ichtyosauria; *14* — Sauropoda; *15* — Squamata; *16* — Archosauria (*16a* — Thecodontia, *16b* — Crocodilia, *16c* — Dinosauria, *16d* — Pterosauria); *17* — Archaeopteryges; *18* — Odontornithes and Neornithes; *19* — Multituberculata; *20* — Monotremata; *21* — Marsupialia; *22* — Trituberculata; *23* — Placentalia.

cies composition of animals. The end of the Permian, the Triassic and Jurassic periods were distinguished by a great variety of reptiles. The seas were inhabited by Testudines, Crocodilia, Ichthyosauria, Plesiosauria; on land there were Dinosauria, and in the air Pterosauria, which later became predecessors of Archeopteryges.

Odontornithes appeared in the Gretaceous period at the end of which Dinosauria and Pterosauria died out.

The beginning of the Cenozoic era saw the apperance of more viable birds and mammals due to further development of the brain, homothermous qualities and viviparity (Cetacea, Pinnipedia, bats). At the end of Paleogene and at the beginning of Neogene, invertebrates became more and more similar to modern species: amphibians, reptiles and birds continue to develop further.

In Australia, Marsupialia survived, and in other continents Placentalia mammals became prevalent. The distinctive feature of the Neogene period is a wide distribution of Hipparion fauna comprising three-toed horses (hipparion), rhinoceros, mastodons, deer, carnivores, and various apes and monkeys. In the Quaternary period, major glaciations changed the animal kingdom of the Northern Hemisphere. Mammoths and woolly rhinoceros came into being and died out. In this period the appearance of man became one of the most significant stages in the development of the biosphere [28]. (The boun-

daries of the biosphere are not conclusively established; they are determined by temperature conditions and by the presence of a sufficient amount of carbon dioxide, oxygen and water.)

Theories of the Origin of Life on the Earth

According to scientists, life originated in the environment some 2.5 to 3 thousand million years ago. Yet, up to the present, despite the outstanding achievements of scientific and engineering thought, mankind cannot give a definite answer to this question. It was believed for a long time that new organisms could have arisen from the decomposition of some other organisms and that nonliving matter was the source for the formation of living things. Religion regards the appearance of life as the manifestation of nonmaterial forces of 'a higher spiritual world', 'the soul of the world spirit', 'vital force', 'divine intellect', 'act of creation', etc. According to theological theories, matter itself is lifeless and serves only as a material for the formation of living organisms. Theologians affirm that life came about because God breathed into lifeless flesh a vital part of divinity.

According to F. Engels, life is a way of existence for protein bodies [29].

At the present time, the theory of the origin of life on the Earth elaborated by the Soviet scientist Oparin has received wide recognition. According to Oparin, life appeared as result of the evolution of carbonic compounds, chemical evolution and the transition of chemical evolution into biological one. Oparin and the American scientist Urey believe that the initial atmosphere and the life that subsequently appeared became possible due to a combined action of gaseous hydrogen, water vapour, carbon and nitrogen compounds. Oparin's theory is confirmed by works on abiogenous synthesis written by scientists of various countries.

Prominent among other theories is that of the American scientist Fox who studied microspheres which represent globular formations resulting from dissolution and subsequent condensation of protein-like substances obtained by using the abiogenous method. In the process of synthesis of these substances, guanine and fatty acids are formed. This provides good grounds for regarding the microsphere as an interesting object for studying one way in which cells appear. According to the British scientist Goldaker [30], a spontaneous formation of surface films and elementary membranes could be one way of accounting for the appearance of phase-detached systems of organic substances.

Additional Information

The abiologic (abiogenous) synthesis of organic from inorganic molecules was the first step to life's origin on the Earth. In ancient times the formation of organic compounds could take place on the Earth. Organic molecules interacted to form more complex compounds. During millions of years innumerable forms of new compounds — from the simplest to the most complex and high-molecular — arose and disintegrated. Some of these may have included substances of any class of organic compounds: carbohydrates, fats, proteins and nucleic acids.

Organic substances accumulated in the water of the primeval ocean. They were originally in the form of a very weak solution. But life is characterized not by a uniform distribution of matter, but by its concentration and by the formation of individual systems isolated from the external environment, i. e. organisms.

The process of concentration of organic substances was the second step

of origin of life on the Earth. It is difficult to say how this process took place. It is possible that clots of organic matter settled on the coastal sand or separated out on the water surface as foam. Oparin believes that this process was most probably due to the ability inherent in all high-molecular substances to spontaneously concentrate and to form coacervates. The phenomenon of coacervation consists in the fact that under certain conditions (e. g. in the presence of electrolytes) high-molecular substances separate from the solution — not as sediment, but rather as a more concentrated part of the same solution. Thus, the solution, while remaining a liquid, becomes two unmixable solutions which differ in a concentration of high-molecular substance. A more concentrated solution is called coacervate.

When coacervate is shaken up, it breaks up into small droplets which are essentially a multimolecular system of the simplest organization. Owing to a higher concentration of organic substances in coacervate and, consequently, owing to a closer arrangement of molecules, a possibility of their interaction sharply increases. Hence, concentration of organic substances considerably broadens a possibility of organic synthesis. Although coacervates outwardly resemble living things in their shape and in certain properties, they certainly are inanimate formations. They still lack the main property of a living organism — the ability to reproduce the same molecules which enter its composition, neither do they have the ability of self-renewal of their composition, which is so characteristic of a living system.

The emergence of the process of self-reproduction of molecules was the third and last stage in the creation of life. It is not improbable that the first self-reproducing molecules could have been polynucleotides. The primeval polynucleotides most likely were much simpler than the modern ones and contained only ten to twenty links. Seemingly, the reduplication process was much slower than at present. But the assembling of one molecule on another molecule of the same structure and composition meant the appearance of a new principle of chemical synthesis — the matrix synthesis which is so characteristic of living systems.

The history of this transition from coacervates to the simplest systems capable of self-reproduction is as yet rather obscure. In modern cells, this process, in addition to self-reproducing molecules, also involves enzymes which catalyze the process of 'sewing together' polynucleatides. For this process to occur, the presence of energy supplying ATP molecules is required. It is possible, however, that all the components necessary for the self-reproduction process were present in the water of the primeval ocean and were absorbed by coacervate droplets. It is not improbable that primeval living beings were similar to modern viruses which, by their composition, represent almost pure polynucleotides. True, modern viruses are capable of reproducing themselves only within a living cell. It is possible, however, that at the dawn of life the predecessors of modern viruses could reproduce themselves in coacervate droplets because the latter may have had all the necessary conditions for it.

By their method of nutrition the primeval organisms were real heterotrophs since they used available organic substances. In that period, nutrition was not yet an acute problem: the primeval ocean contained a sufficient amount of various compounds. Yet, as organisms decomposed, the reserves of organic substances diminished and the synthesis of new ones failed to keep up demand. Hence, a struggle for food began, in which more active, viable and adapted organisms survived. The pro-

tective properties acquired accidentally as a result of hereditary variations or structural and metabolic peculiarities were retained and preserved in the course of selection if they gave even slight advantages for survival. Apparently, due to selection many properties of living formations became inherent in them, which led to the transformation of primeval organisms into modern viruses and cells.

Another major step in the evolution of life was the development of autotrophic nutrition. With ever-decreasing reserves or organic compounds, certain organisms developed an ability to independently synthesize organic compounds from simple inorganic substances of the environment. Some of the organisms began to release the energy required for such a synthesis by the simplest chemical reactions of oxidation and reduction. Thus chemosynthesis developed and is still a source of energy in certain bacteria.

The emergence of photosynthesis was a particularly significant progressive change of aromorphosis type. In the period of life's genesis there was no free oxygen left either in the atmosphere or in the ocean: this active element was linked with other elements and entered into the composition of various inorganic substances. Thus, organisms originally received energy by way of oxygen-free reactions of organic substances. With the development of photosynthesis and with the appearance of free oxygen in the atmosphere and water, there emerged a new form of energy release — an oxygen way of splitting.

Photosynthesis contributed to the development of life on the Earth in still another way. The fact is that during the period when life was beginning the Earth was subjected to intensive and destructive solar radiation. Since water absorbs radiation, life was originally possible only in the ocean. As photosynthesizing organisms developed and oxygen accumulated, part of it turned into ozone which is capable of intensively absorbing ultra-violet and ionizing radiation. As a result, the desstructive radiation diminished and life became possible on land. Life came out of water and spread all over the entire surface of the Earth [31].

Geographical Structure of Biosphere

The geographical structure of the biosphere is based on the principle of the zonality of natural landscapes, taking into account their heat (radiative) and water balances. The radiative balance is determined by the difference between the absorbed solar energy and the long-wave radiation reflected by the Earth's surface. One of the indicators of this balance is the radiative dryness index characterized by the ratio of the radiative emission on the Earth's surface to the dissipation of heat due to evaporation of the annual amount of precipitation. Twenty main types of natural landscapes may be distinguished, including artic desert, tundra, northern and middle taiga; southern taiga and mixed forest; leaf-bearing forest and forest-steppe, steppe, temperate zone semidesert, temperate zone desert distícts of subtropical forests, rain subtropical forests, subtropical sclerophylous forest and shrubs, subtropical steppe, subtropical semidesert, subtropical desert, districts of prevalent equatorial wooded swamps, markedly swampy equatorial forests; medium swampy equatorial forests, equatorial forests, equatorial forests changing to light tropical forests and wooded savannas, dry savanna, desertificated savanna and tropical desert.

Different correlations between heat and humidity in geographical zones exercise various influences on the amount of vegetative mass in this or that area. The types of ecological system and

Table 2

Phytomass and Its Annual Production on the Earth's Surface

Geographical zones and regions	Phytomass		Annual production	
	average (t/year)	total (10^9t)	average (t/year)	total (10^9 t)
Boreal, humid and semihumid	189	439.1	7	15.2
Subboreal	124	278.5	8	17.9
Including:				
humid	342	253.5	13	9.3
semiarid	21	16.8	8	6.6
arid	12	8.2	3	2
Subtropical	134	323.9	14	34.5
Including:				
humid	366	228.4	26	15.9
semiarid	99	81.9	14	11.5
arid	14	13.6	7	7.1
Tropical	243	1347.2	19	102.5
Including:				
humid	440	1166.2	29	77.3
semiarid	107	172	14	22.6
arid	7	9	2	2.6
Glaciers	0	0	0	0
Lakes, rivers	0.2	0.1	5	1
Land	161	2402	11	172.5
Ocean	0.005	0.2	2	60
Entire Earth	47	2402.7	5	232.5

the reserves of their phytomass are essentially determined by radiative and water balance (Table 2) [24].

As may be seen from the Table, depending on indices of radiative balance, geographical zones are characterized by different ecological systems: humid — with an excessive quantity of moisture, semiarid — with a limited quantity of moisture, and arid — with considerable moisture deficit. The same factor determines differences in the amount of vegetative mass which is equal to $2.4 \cdot 10^{12}$ tons, or about 2/3 of the entire biomass of the Earth. The annual increase of the vegetative mass makes up 10 per cent. The production of this mass is ensured in the biosphere by only 2 per cent of the solar energy coming to the Earth, which is indicative of the great energy potentialities of the biosphere. This factor may have an appreciable effect on the subsequent development of the biosphere structural units [24].

Ecological Systems and Their Biological Effectiveness

The ecological system which is the primary structural unit of the biosphere represents a functional system including communities of living (plant and animal) organisms and their habitat. All organisms are inseparably linked with the environment and are in continual interaction. The most characteristic feature of the ecological system (ecosystem) is the presence of interdependences and cause-and-effect relationships. The ecological system comprises the biological entirety of the plant and animal kingdoms, microorganisms (biome) and their natural conditions (atmosphere, soil, rocks and humidity).

According to Odum [21], the ecosystem composition includes the following main components: inorganic matter (carbon, nitrogen, carbon, dioxide, water, etc.) involved in cycles of substances; organic compounds (proteins, carbohydrates, lipids, humic substances, etc.) linking biotic and abiotic parts; climatic conditions (temperature, and other physical factors); producers (autotrophic organisms, mainly green plants that are capable of producing food from simple inorganic substances); macroconsumers, or phagotrophs,— heterotrophic organisms, mainly animals which feed on other organisms, or particles of organic matter: microconsumers, saprotrophs, or osmotrophs,— heterotrophic organisms, mainly bacteria and fungi which destroy complex compounds of dead protoplasms, absorb some products of decomposition and release inorganic nutrients to be utilized by producers, and also organic

substances which can serve as energy sources, inhibitors or stimulators for other biotic components of the ecosystem. The first three groups are nonliving components while the remaining constitute the biomass.

A complex interaction and interlacing of living components in ecosystems ensure food and chorological links, trophic chains and nets. Duvigneaud and Tanghe [23] singled out the following main groups of food chains:

Carnivore chains. These begin with producers assimilating mineral substances from the abiotic environment, and are continued by plant-eating animals which feed on producers and, in turn, serve as food for small carnivores that are devoured by larger ones, etc.

Parasite chains. In contrast to the previous chain, these begin with organisms of a relatively large size and are continued by smaller ones.

Saprophage chains. Those begin with dead organic substances and are continued most commonly by microscopic organisms.

One and the same producer may serve as food for various plant-eating animals, and the latter, as food for various carnivores. As a result, a complex multitude of food chains are created in the biome, interlacing to form a trophic (food) chain.

The chorological links of organisms are determined by their constant struggle for space, light, food, water, resistance to enemies and unfavourable conditions. The basic data on the ecosystem are given in Fig. 14.

As far as their level of organization and size are concerned, the following three types of ecosystems may be distinguished: microsystem (e. g. wood stump), mesoecosystems (e. g. forest association) and macroecosystem (e. g. ocean). According to these types, the biological effectiveness of ecosystems is established, as seen in the work performed by Duvigneaud and Tanghe together with staff members of L'Université Libre de Bruxelles (ULB) and graphically presented in Figs 13 and 14.

In the ecological system of the Central European forests shown in Fig. 13, as much as 24 tons of dry vegetative matter is produced annually per hectare by photosynthesis utilizing 1 per cent of solar energy and atmosphere carbonic acid; half of this amount is lost due to respiration, while the remaining 12 tons is distributed in the following manner: grass — 1 ton, roots — 2 tons, leaves — 4 tons and xylem — 5 tons.

Protecting themselves against microorganisms, certain actynomyces and mold fungi produce substances (streptomycin, penicillin) used by man to combat pathogenic bacteria.

Nitrifying bacteria transform nitrogen of organic matter into nitrates. Other bacteria and fungi decompose humus into carbon dioxide and water, thus liberating inorganic substances (mineralization) and returning to plants Ca^{2+}, K^{+}, Mg^{2+}, PO_4^{3-} in the form of mineral salts; these microorganisms are capable of decomposing during twenty-four hours the amount of matter which exceeds their own biomass by a factor of 100 to 1000.

Soil animals break up organic matter into small particles, including them in their excrements. Earthworms mix up organic matter with mineral particles of soil in their excrements whose mass reaches 5 tons per hectare. These various substances are subjected to the action of bacteria producing soft humus (mull). Some soil fungi turn organic matter into a black layer of coarse humus (mor).

The ecological system of the ocean shown in Fig. 17 is inhabited by 40 thousand whales, 30 million tons of fish and 3 million tons of invertebrate organisms, with phytoplankton (microscopic chlorophyll-bearing algae and also blue-green algae) forming 27 thousand million tons of organic matter.

Phytoplankton serves as food for zooplankton — small plant-eating organisms including copepods, fry, larval stages of various marine invertebrates. Zooplankton, in its turn, serves as food for the first groups of carnivores inhabiting the surface layers of waters; this group is subdivided into neuston (passively floating organisms) and nekton (actively swimming organisms). Carnivores of the second order, for example, sharks and tuna, feed on nekton. Death turns organisms into food reserves for various microorganisms. In this phase of the cycle, invertebrates, which restore organic matter, transform dead bodies into mineral salts, and bacteria perform the final mineralization. Mineral elements rise to the surface only with upward streams. Surface waters contain from 0 to 0.08 mg/l of nitrogen and from 0.002 to 0.03 mg/l of phosphorus, whereas at deeper layers, starting from a 1,000 m depth, the nitrogen content increases from 0.12 to 0.4 mg/l and that of phosphorus — from 0.005 to 0.06 mg/l.

Despite the enormous productivity of the oceans, man so far uses only 1 per cent of its resources, or less than 5 per cent of proteins [32].

Noosphere

With the evolutional development of the biosphere and scientific and engineering thought, with ever deeper penetration into the secrets of nature, humanity is becoming a powerful ecological force that transforms the appearance of our planet.

This can be explained by the following facts. First, by the continuous growth of the world population. If towards the beginning of the first century A. D. its number did not exceed 130 million and 1000 years later increased only by 45 million and after another 900 years, by 1,340 million, over the past thirty years the population of the planet has already grown by more than 1,500 million. In 1980 there were 4,400 million people living on the Earth, and in 2000 this figure is expected to reach approximately 6,500 million. This number of the Earth's population will have a noticeable effect on the biospheric formations and processes since the annual amount of consumed O_2 will exceed 2,000 million tons and the amount of liberated CO_2 will approach 3,000 million tons. In combination with industrial effects this will bring about changes in the composition of the atmosphere whose ecological consequences will, no doubt, affect the systems supporting the life of man and of the plant and animal kingdoms.

Second, humanity ecological force can be explained by the accelerated scientific and technical progress and its basic component — scientific and technological revolution. Mechanization, automation and chemicalization of production, have brought about radical qualitative changes both in the development of human and other productive forces and in technological effects on natural systems. This has led to a sharp increase in the amount of natural resources involved in economic activity.

During the entire period of civilization humanity has used from 80 to 85 thousand million tons of various types of fuel, during the 19th century alone 22,711 thousand tons of lead, 11,375 thousand tons of zinc, 10,679 thousand tons of silver, 11,5 thousand tons of gold, 25,5 thousand tons of aluminum, etc., were extracted. At the present time at least 4 cubic kilometres of rock is annually mined and delivered to the earth's surface. By the year 2000, the amount of coal, petroleum, firewood burnt all over the world will be respectively 2-2.5, 3.5-4 and 1.5-1.8 times as high as in 1965. As of today, man has developed and changed in one way or another virgin landscapes in 55 per cent of the earth's surface and changed them

Table 3

Growth Rates of the Earth's Population and World Industrial Production for 20 Years

Population and industrial production	Annual increase, %		
	minimum	maximum	average
Population	1.3	2.1	1.75
Vegetable food	2.05	3.32	2.70
Animal produce and fish catch	1.75	6.11	3.81
Fuel and combustibles	1.63	6.81	3.91
Nonmetallic ores	4.33	6.17	5.15
Metallic ores	3.48	8.92	5.42
Metals	4.26	9.16	6.08
Inorganic chemical products	2.47	9.45	6.17
Petrochemical products	—	—	12.04
Chemical synthetic materials	15.72	15.96	15.84

considerably or radically in 1/5 of the total area of land [33].

According to the estimates of Seferovitch [34], over the past 20 years the growth rates of the Earth's population and of world industrial production were as follows (Table 3).

For this period, the annual growth rate of population lagged behind the production of vegetable food by 1.54 times, of animal produce and fish — 2.18 times, fuel and combustibles — 2.23 times, nonmetallic ores — 2.94 times, metallic ores — 3.1 times, metals — 3.47 times, inorganic chemical products — 3.58 times, petrochemical products — 6.88 times and chemical synthetic materials — 9.1 times. Owing to the achievements of solid-state physics and polymer chemistry, the discoveries in physics and chemistry of semiconductors, the ever-increasing peaceful use of atomic and thermonuclear energy, the energy of the Sun, oceans and winds, and also due to many other achievements of modern scientific and engineering thought, mankind, as part of the living matter of the Earth, extends the boundaries of the biosphere by carrying out large-scale transformations and exerting an immense influence on the environment, and gradually passes to the era of noosphere, i. e. to a reasonable and controllable use of its ecological resources in the name of peace and progress on the Earth. Man has already flown into outer space, landed on the Moon, sunk into the ocean depths and his spaceships reached Venus. All of this enables one to view the transformation of the biosphere by the human intellect in a new light and points to a possibility of a qualitatively new stage emerging in the relationship between man and nature — the stage of noosphere.

Nature and Natural Resources

Nature is the world surrounding us in all its diversity of phenomena and objects. Nature's development follows the laws of evolution, movement and change. From the philosophical standpoint nature is objective reality existing in perpetual flow and turnover regardless of will and consciousness of man. From the point of view of natural history nature is the object of study of different sciences, including ecology, biology, zoology, geology, chemistry, physics, mathematics, astronomy, etc. which help determine general laws of nature and of phenomena in the universe. From the standpoint of human society, nature is regarded as a totality of natural conditions for the existence of life on the Earth. The term 'nature' is very often used to express the essence and characteristic features of processes, phenomena and categories, which reveal their basic content to the utmost degree.

With the development of ecological processes in the course of the evolution of the biosphere, with the appearance of animals and human beings, natural living conditions for organisms chan-

ged drastically. But an animal only uses the surrounding natural environment, bringing about changes simply by virtue of its presence; man, by introducing changes, makes the environment serve his purposes and dominates it. And this is the last substantial difference distinguishing man from the rest of animals, and again man owes this distinction to labour [29].

The satisfaction of man's immediate requirements in food, shelter and clothing, ultimately became the motive power behind all changes taking place in nature. A simplified diagram of this process is given in Fig. 16. Man's influence upon the natural environment started from the moment he appeared in the biosphere. During the period of hunting, fishing and gathering, ecosystems were self-controlled because the predatory activity of primitive tribes did not affect the established rhythm and fundamental biological laws of natural conditions.

But, as Dorst points out, hunters, appearing at a higher stage of development, used to set forests on fire in order to make the chase of animals, stupefied by fire, easier. Forest fires, which have periodically resulted from the hunter's activities especially in Africa, have caused a tremendous damage to plant communities by completely modifying them. This demonstrates that even in olden times man could seriously disturb the balance of nature, thus speeding up erosion and other changes in the landscape [35].

With the development of cattle-breeding and the domestication of wild animals, the influence of man upon the natural environment become more pronounced. The need to improve living conditions led to frequent migration of animals and men, thus bringing about fires, destroying vegetation, primarily forests in vast territories. As a result, erosion processes intensified, boundaries of deserts and semideserts expanded, the climate changed, many species of animals and plants became extinct since they never adapted to the new natural habitat. Having considerably enhanced man's possibilities in providing himself with foodstuffs, the cattle-breeding system and nomadic life dealt the first severe blow to ecological systems.

The further disturbance of the balance of nature is closely associated with farming and the invention of the plough leading to an increase in the area of tilled land and, in turn, to diminishing fertility and to the initial stage of soil degradation. This process was also greatly promoted by the introduction of farming systems of the cutting-and-firing type.

Historically the 15th-17th centuries experienced the greatest geographical discoveries and the opening of nearly all territories of the terrestrial surface. They also gave a sharp impetus to the extraction of mineral resources and their continuous exploitation with the aim of gaining profits and acquiring wealth. Geographical discoveries coincided with the development of tools and means of production and the formation of large economic, cultural and commercial centres. The period of those discoveries was simultaneously a period of radical changes in the interrelationship between man and the natural environment. It was during this stage of mankind's history that changes in ecological systems started taking place on a large scale, and their consequences are still having a detrimental effect on ecosystems. The deep-rooted system of unpractical farming resulted in an even more pronounced deterioration of the process.

The end of feudalism and the initial stage of capitalism were marked by significant changes in production means and tools. Objective conditions for the transition from manufactory to large-scale machine industry and for the

concentration of industrial production arose as a result of initial capital accumulation, the population growth of the poor and the concentration of money and natural resources by the few. The invention of the steam-engine further accelerated this process.

The transition from the manufactory to large-scale machine industry also brought about drastic changes in the raw material base of industry, i. e. it sharply increased the exploitation of natural resources, in turn the starting point for the revolution in the biogeochemical structure of the biosphere. By 1860 the world-wide consumption of fuel equivalent (including substitutes) had already reached 469 million tons, including 317 million tons of firewood, 137 million tons of coal, 6 million tons of peat, 4.9 million tons of natural casing-head and oil gas, 0.1 million tons of oil, or 0.44 tons per capita [36].

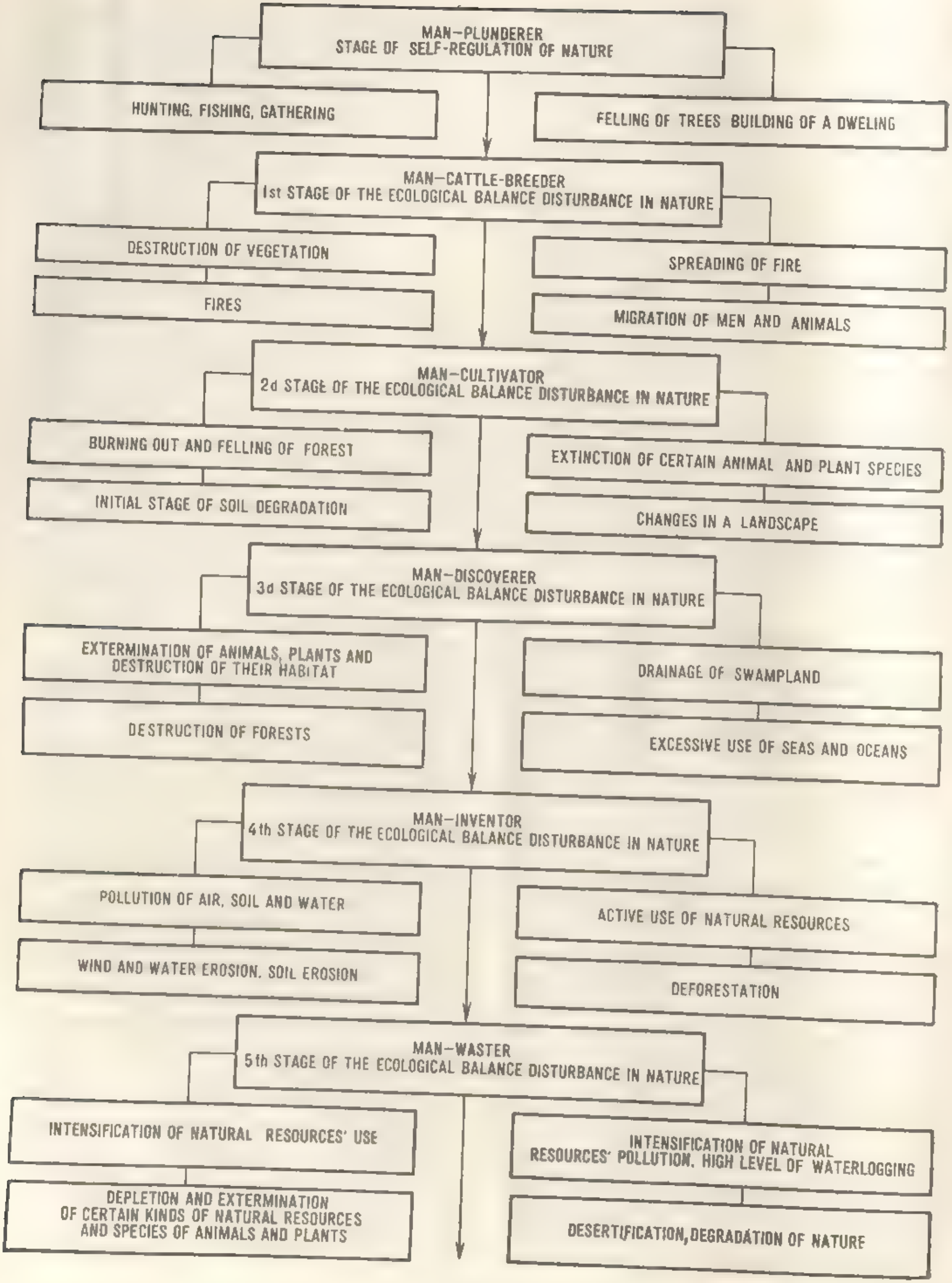
The vast growth of industrial and agricultural production revolutionized man's influence upon ecological systems and intensified the initial stage of air, soil and river contamination, and the process of wind and water erosion and deforestation. The changes in the environment due to man-made activities were local and were mainly grouped within areas of large-scale machine production, but even then these changes began to have a harmful effect on human health.

These phenomena reached their summit on a world-wide scale in the 20th century, at the time of the scientific and technological revolution which was marked by the introduction of an entirely new process of raw materials and energy production, by a qualitative leap in the production of means of production and the industrial output of new items with diverse technological, economic, physical and chemical properties. During a period of 65 years (1913-1978),, world production of commercial coal increased 2.6 times, cereal and leguminous crops — 3.4 times, cast iron — 6.2 times, steel — 9.4 times, cement — 20.1 times, mineral fertilizers — 23.5 times, oil (including gas condensate) — 54.1 times, natural gas — 87 times, synthetic resin and plastic materials, man-made fibres and threads — 115 times, electricity — 124.2 times.

The modern development of science and technology, combining different ways of world economic development, led too often to a wasteful intensification of the exploitation of natural resources. This resulted in a reduction of arable lands and deterioration of their quality: to a depletion of formerly rich coal fields, gas and oil deposits, and the destruction of forests: to extermination of large numbers of plants and animals: desertification; the diminishing of fresh water; and to intensified pollution of the atmosphere accompanied by a sharp outbreak of cardiovascular, cancerous and infectious diseases.

Immediate measures are urgently needed in order to eliminate disproportions which have arisen in the interrelationship of biosphere resources and thereby ensure that the intensified development of world productive forces will not disturb the ecological balance and will in every possible way favour the harmonization of ecological systems and human beings.

The ever-growing pace of scientific and technological progress and the urgent need for the solution of large-scale socio-economic tasks require the involvement of additional amounts of natural resources in economic turnover during the coming decades. This problem should be regarded as singular through complex, ensuring the most favourable conditions for the development of present and future generations. Its growing importance is mainly due to the fact the 1980s and 1990s will be marked by the coexistence of new ma-


MAN—PLUNDERER
STAGE OF SELF-REGULATION OF NATURE
HUNTING, FISHING, GATHERING
FELLING OF TREES BUILDING OF A DWELING
MAN—CATTLE-BREEDER
1st STAGE OF THE ECOLOGICAL BALANCE DISTURBANCE IN NATURE
DESTRUCTION OF VEGETATION
FIRES
SPREADING OF FIRE
MIGRATION OF MEN AND ANIMALS
MAN—CULTIVATOR
2d STAGE OF THE ECOLOGICAL BALANCE DISTURBANCE IN NATURE
BURNING OUT AND FELLING OF FOREST
INITIAL STAGE OF SOIL DEGRADATION
EXTINCTION OF CERTAIN ANIMAL AND PLANT SPECIES
CHANGES IN A LANDSCAPE
MAN—DISCOVERER
3d STAGE OF THE ECOLOGICAL BALANCE DISTURBANCE IN NATURE
EXTERMINATION OF ANIMALS, PLANTS AND DESTRUCTION OF THEIR HABITAT
DESTRUCTION OF FORESTS
DRAINAGE OF SWAMPLAND
EXCESSIVE USE OF SEAS AND OCEANS
MAN—INVENTOR
4th STAGE OF THE ECOLOGICAL BALANCE DISTURBANCE IN NATURE
POLLUTION OF AIR, SOIL AND WATER
WIND AND WATER EROSION, SOIL EROSION
ACTIVE USE OF NATURAL RESOURCES
DEFORESTATION
MAN—WASTER
5th STAGE OF THE ECOLOGICAL BALANCE DISTURBANCE IN NATURE
INTENSIFICATION OF NATURAL RESOURCES' USE
DEPLETION AND EXTERMINATION OF CERTAIN KINDS OF NATURAL RESOURCES AND SPECIES OF ANIMALS AND PLANTS
INTENSIFICATION OF NATURAL RESOURCES' POLLUTION, HIGH LEVEL OF WATERLOGGING
DESERTIFICATION, DEGRADATION OF NATURE

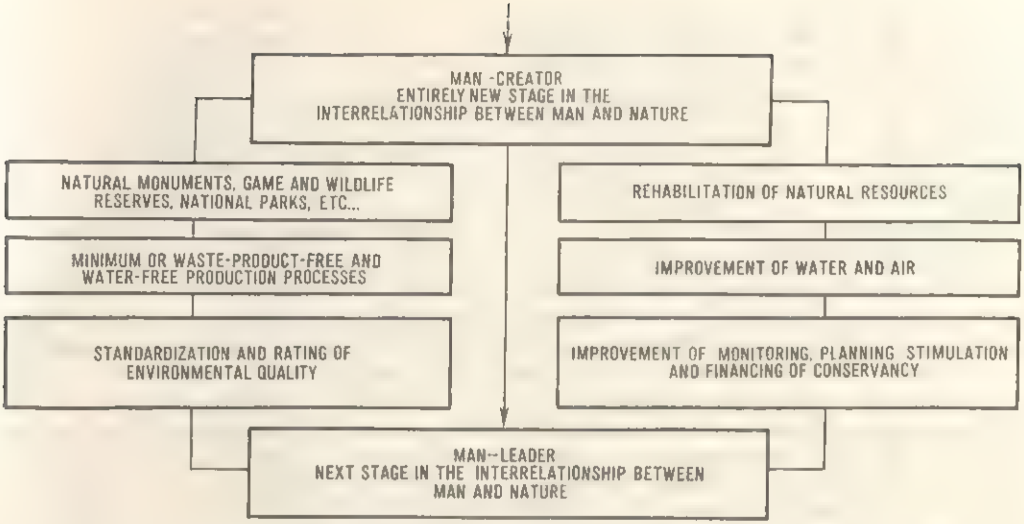


Fig. 16. Man-nature interrelation stages.

chinery and technology, on the one hand, and, on the other, conventional old machinery and technology, created in the 1940s and 1950s, partially modified but still involving pollution. Most experts are of the opinion that this is the most important aspect of the present stage in scientific and technological progress and the particularity of world material production. The early formation of a new stage is not likely to occur before the 1990s, when machinery and technology are environmentally sound, adequate to meet to modern scientific and technological developments and able to predominate in all basic spheres of production.

Such a peculiarity in the long-term development of industry is conditioned by the time gaps in the implementation and introduction of scientific and technological advances. This means, first, that the basic features of this stage of material production will be mainly determined by the enormous sluggishness of the industrial complex. This sluggishness is gaining strength due to the fact that a considerable part of the industrial complex is still producing conventional machinery, thus maintaining its prevailing position in the near future. Second, is a considerable time gap between different stages of scientific and technological progress, beginning with a hypothesis and discovery and leading to the introduction of its results into economic activity. Hence, the ever-growing scale of world industry development will affect human organisms, and animate nature as a whole, at an increasing rate because of its environmental consequences.

In the light of the foregoing, the solution of environment control problems in most countries calls not only for further improvement in production techniques but for a considerable expansion of ecological, biological, physiological, and economic feasibility studies aimed at the most complete satisfaction of the population's demands as to the quality and diversity of the environment; promotion of the harmonious interaction of different socio-economic systems with the environment, having due regard to national peculiarities in the development of scientific and technological progress and the corresponding demo-

graphic tendencies; increased comprehensiveness of exploitation of natural resources; preservation and improvement of natural potentialities in the interests of future generations; a reliable long-term prediction of natural processes and their influence upon economic activity: and improved control of these processes.

With this in mind and, on the basis of experience gained by both industrialized and agrarian countries, it is necessary for third-world countries to analyze thoroughly the ecological and economic nature of anthropogenic effects on the environment and to work out methods for the quantitative and qualitative evaluation of man's influence upon ecological systems and their complexes, in order to offset the deficit of water resources in countries with a low water supply, to rationalize water consumption, to ensure the conservation, rehabilitation and expansion of the land area with greater productive capacity in formerly cultivated regions; to make sure that the expansion of farming lands is not at the expense of wildlife reserves or lead to drastic deforestation, etc., to enhance the biological productivity of natural and man-modified ecosystems while maintaining the ecological balance, to eliminate or sharply diminish the release of industrial, agricultural and residential waste products into the environment by developing and introducing rational methods of power-generating fuel burning, waste-free and closed production techniques and complex processing of raw materials and industrial wastes; to ensure the rational exploitation of the natural resources of the world's largest regions; to increase the accuracy, reliability and long-term viability of hydrological and meteorological forecasts, to build up and expand international systems of conservation and environmental control.

Classification of Natural Resources

Natural resources are elements of nature, which serve as primary sources for man's existence. They fall into the following groups: planetary and outer space; climatic; fossil (geological and mineral); water, land; vegetation and animal; atomic. Owen [19] gives the following classification of natural resources as with reference to their degree of exhaustibility and cause-and-effect relationship:

I. Inexhaustible resources

A. Perpetual

1. Atomic energy
2. Wind energy
3. Precipitation
4. High- and low-tide energy

B. Apt to diminish when used improperly

1. Solar energy
2. Atmosphere
3. Water of oceans, lakes and rivers
4. Water stream energy
5. Landscape in the broadest meaning of the world

II. Exhaustible resources

A. Resources that can be conserved

1. Renewable resources
   a) water
   b) soil
   c) land produce
      1) agricultural produce
      2) forests
      3) haylands
      4) wild animals
   d) products of lakes, rivers and reservoirs
   e) products of the ocean
   f) manpower resources
2. Nonrenewable resources
   a) species of wild animals
   b) virgin nature

B. Resources that cannot be conserved

1. Reusable resources
   a) precious stones
   b) reusable metals
2. Resources that cannot be reused
   a) fuel mineral resources
   b) most nonmetallic minerals
   c) metals whole utilization exhausts their reserves

Economic classification of natural resources is based on the character of their exploitation in productive and nonproductive spheres. The need for economic classification of natural resources requires proper analysis and planning in order to take measures aimed at improving a complex exploitation of biosphere resourses and preventing their depletion. Economic classification of natural resources on a global, i. e. international, scale is of particular importance, for this classification will be of considerable help in promoting mutual understanding between countries and peoples in the field of international co-operation on the exploitation of environmental resources and clarifying a number of disputed and highly controversial issues. The classification suggested by Mintz might constitute a standard basis for such a gradation (Table 4).

World Natural Resources

As far as their legal status is concerned, world natural resources, fall into two categories: international and domestic (national). Within the first category the most significant are those which are universal, or as environmentalists sometimes express it, 'common to all mankind', 'common to the people', or 'pertaining to the Earth', and shared by all states and peoples with no exception whatsoever. By this we mean, first of all, resources of the open sea (with due regard for the rights of coastal countries), natural resourses of the Antarctic Continent within the jurisdiction zone of the 1959 Antarctic Treaty, space bodies and the atmospheric air. Unlike international resources, water and fishery resources of international and border rivers, canals and lakes as well as terrestrial animals migrating across boundaries are common property of certain states (i. e. are multinational natural resources) at the same time retaining their international quality. Natural sciences and nature management offer proof of the fact that, given the sharply increasing influence of man upon the natural environment, the rational long-term exploitation of natural resources by states depends on co-operative and co-ordinated measures aimed at the preservation and development of those gifts of nature. Similar internation actions for rational nature management are beneficial to all the countries and peoples concerned when base on a broad notion of 'international natural resources'.

From the standpoint of international law and practice it is reasonable to consider as international such natural objects as, in the process of their natural cycle, without the influence of man, permanently or, at least, for any part of the year, are within the range of international space (open sea, within the juridical zone of the Antarctic Treaty, etc.) or at different times of a year are within the territories of different states.

Taking into consideration the humane content of international law regulating the interrelationship of states in nature management, it is necessary to emphasize that no country has a legal right to exercise its sovereignty over any part of an international resource, whether in international space or within a state's territory. It is also illegal due to the fact that the above-mentioned nature objects are not an integral part

Table 4

Natural and Economic Classification of Natural Resources

Natural classes of resources	Economic classes of resources			
	Material production			
	Industry			
	Energy resources	Raw materials for manufacturing industrial-purpose structural materials	Raw materials for manufacturing industrial-purpose products	Raw materials for manufacturing consumer goods
Mineral resources	Fuel (oil, gas, coal, peat, shale), radioactive resources (uranium, thorium, etc.)	Ferrous metals, nonferrous and rare metals, nonmetallic raw materials — ceramic materials, abrasive materials, dielectric materials, optical raw materials, building materials, etc	Fuel mineral resources (for refining), agricultural rocks (phosphates, etc.), chemical and technological raw materials of other types (sulphur, mineral salts, precious metals, etc.)	Precious and semiprecious stones
Climatic resources	Wind, solar energy resources	—	—	—

Table 4 *(continuation)*

Natural classes of resources	Economic classes of resources			
	Nonproductive sphere			
	Agriculture			
	Means of growing useful cultivated plants	Means of immediate exploitation of natural plants and animals	Direct consumption	Indirect consumption
Mineral resources	Lime materials, peat	—	—	—
Climatic	Heat, atmospheric moisture	—	—	Complex of climatic factors for rest and medical treatment
Water	Irrigation water	—	Drinking water, medicinal mineral water	Water body for sports and rest
Soil	Soils of arable lands	—	—	Soils of green plantations

Table 4 *(continuation)*

Natural classes of resources	Economic classes of resources			
	Material production			
	Industry			
	Energy resources	Raw materials for manufacturing industrial-purpose structural materials	Raw materials for manufacturing industrial-purpose products	Raw materials for manufacturing consumer goods
Water	Water energy resources	Process water	Process water	Mineral waters for bottling purposes
Soil	—	—	—	—
Vegetation	Forest (firewood, brushwood, grasses	Forest (wood)	Forest (wood, resin, etc.)	Medicinal herbs
Fauna	—	—	Fish (wastes)	Fish (including other sea animals)
Others	Atomic (thermonuclear), geothermal, tide energy	—	Air gases	—

Table 4 *(continuation)*

Natural classes of resources	Economic classes of resources			
	Productive sphere			
	Agriculture			
	Means of growing self cultivated plants	Means of immediate expoltation of natural plants and animals	Direct consumption	Indirect consumption
Vegetation	—	Fodder plants, wild fruits, berries, mushrooms	Wild fruits, berries, mushrooms	Forest and other plant complexes for rest
Fauna	—	Game animals	Game animals	Game and fish for game hunt and fishing
Other	—	—	—	«Aesthetic resources»

of the state territory, and the principle of territorial sovereignty of a state does not affect them.

If the opposite view is accepted, it becomes necessary to adopt the absurd thesis that sovereign rights of different countries apply to one and the same resource (a certain volume of atmospheric air, certain amount of water in an international river, the migrating population of aquatic and terrestrial animals) but during different seasons of the year, in other words that a natural resource may be considered a national natural property when it is within the territory of a certain country, but after leaving that territory and reaching international space it becomes an international resource.

National legislation on environmental control and sanitary environment protection and regulations for the exploitation of natural resources and hunting which do not distinguish a particular

legal status for natural objects under national control probably proceed from the very fact of their physical location within the boundaries of the state rather than from an exercise of sovereignty with respect to those included in an international category. A state can only exercise unilateral measures with respect to an international resource which do not infringe upon the interests of other states, or which either promote a better use of a given resource or protect the states' legitimate rights from predatory exploitation by others.

No part of an international natural resource can become national property unless after it has been withdrawn from nature. For example, animals caught in the open sea; oxygen, nitrogen, and other gases obtained from the atmosphere; migrating wild-fowl and mammals that have been shot; water drained into the limits of a coastal state from international fresh water bodies.

For the first time the main features of the international and legal status of the world natural resources have been defined in full and clear terms in the USSR proposals concerning the adoption by the United Nations General Assembly of an 'International Declaration on Rational Exploitation and Protection of Resources in the Biosphere', submitted for consideration to the Intergovernmental UNESCO Conference on a scientifically grounded approach to the rational exploitation and protection of biosphere resources (Paris, Sent. 4-13, 1968).

The term 'international natural resource' does not only imply a specific legal status of one or another natural object and the relation of close co-operation between states whose citizens are engaged in its exploitation, but it also means that the rights to this resource of the present generations must not come into conflict with the rights of people yet unborne.

Land Resources

The annual production of land biomass amounts to 187,600 million tons, 99.2 per cent of this quantity undergoes destruction, mineralizing to CO_2, NH_3 and other volatile components, while 0.8 per cent, or 1.5008 thou. mill. tons is buried in sediments. Oceanic depths contain 2.7 per cent of organic matter buried during formation of sedimentary rock (biogenic accumulation), shelf and continental slope — 26.3 per cent, inland water bodies — 71 per cent, which makes up 1,065 million tons a year. With an average plant zonality of 10 per cent biogenic accumulation reaches 359 million annually.

Hydrogen and inert helium penetrate into outer space through the upper layers of the ionosphere. Meteorites and cosmic dust penetrate into the Earth's gravitational field from outside. Since its existence the Earth has been receiving about 800,000 million tons of meteoric matter a year. At present, nearly 30 per cent of cosmic matter settles on land, which, according to different estimates, makes up from 0.01 to 24 million tons annually.

Accumulation of clastic material and its transportation to lower layers of the Earth's surface (denudation) on the global scale is partially made up for with accumulation of weathering product, which amounts to about 15 per cent of the expendable segment of the land mineral matter balance, summary data on which are listed in Table 5. At the same time, while determining the size of the above-water part of land, it is necessary to take into account the variability of land and sea boundaries, and the impact of tectonic formations.

Under present conditions, there is an observable and gradual increase in the mass of the hydrosphere, the average rate of which in respect to the entire surface of the Earth is equal to 0.00086-0.00100 mm a year. Against

Table 5

Approximate Balance of Land Mineral Matter

Denudation factors *	Thousand million tons annually
Discharge	
Sediment runoff	14.1
Denudation in areas of recent glacier covering	2.2-2.3
Ionic runoff	1.6-1.7
Marine abrasion	0.7-1.0
Eolian evacuation	2.0-4.0
Mineral fuel combustion	2.6
Total	23.2-25.7
Accretion	
Cohesion of water and matter of atmosphere in weathering	0.1-1.6
Volcanogenic accumulation	1.8
Biogenic accumulation	1.0
Accumulation of matter from outer space	0.000003-0.02
Total	2.9-4.4

* Excluding denudation caused by human activities

this background, there occur global advances and recessions of the sea related to movements taking place during geologic epochs as well as to variations in the ratio of solid and fluid phases of water.

If the Earth's crust remained calm tectonically, the land volume, at the present rate of ocean-level elevation, would be reduced annually by 90-500 thousand million tons [20].

World Ocean Resources

These include water, vegetation, animal and mineral resources.

Water resources. The total amount of water on the Earth is 1,386 million cubic kilometres, the World Ocean accounting for 1,338 million cubic kilometres, or 96.5 per cent. The fresh water accounts for 35 million cubic kilometres, and its distribution in the hydrosphere is shown in Table 6 [37].

Thus, glaciers and snow cover account for 69.6 per cent of the total amount of fresh water. The second largest source of fresh water resources is underground water; it constitutes 30 per cent of the total amount of fresh water and this, according to present-day estimates, exceeds the volume of water in river beds by a factor of 43.3.

The world's largest natural fresh water body is Lake Superior in North America with a water plane area of 82,680 square kilometres. The amount of water in 143 of the largest man-made lakes (reservoirs) of the world with a cubic content over 5 cubic kilometres is 4286 cubic kilometres. The world's largest man-made reservoir in area is that of the Volta River (8,500 square kilometres), and the greatest volume is represented by the reservoir on the Victoria-Nile River (205 cubic kilometres).

Swamps that take up 2 per cent of land, or 3 million square kilometres, also provide a source of fresh water. Nearly 60 per cent of the total number of swamps are within the USSR, while South America is the most swampy

Table 6

Distribution of Fresh Water on the Earth (acc. to Spengler, 1980)

Hydrosphere parts	Volume thousand km^3
Glaciers, underground ice, constant snow cover (in terms of water)	24,364.0
Underground waters	10,530.0
Fresh water lakes	91.0
Soil moisture	16.5
Water in atmosphere	12.9
Bogs	11.5
Water in river beds	2.1
Biological water (in living organisms)	1.1
Total	35,029.1

Table 7

Water Balance and River Runoff Supply of Continents Together with Islands and Internal Runoff Areas (rounded values correlated with balance)

Continents	Area, thou. km²	Volume, km³/year			Layer, mm/year			River runoff supply			Runoff coefficient
		precipitation	runoff	evaporation	precipitation	runoff	evaporation	runoff	from 1 km²	runoff per capita, thou. m³/year *	
Africa	30 120	22 350	4 570	17 780	742	151	591	152	4.8	15.8	0.20
North America	24 200	18 300	8 200	10 100	756	339	417	339	10.7	25.1	0.45
South America	17 800	28 400	11 760	16 640	1 600	660	940	661	21.0	63.6	0.41
Antarctic	13 980	2 310	2 310	0	165	165	0	—	—	—	—
Asia	43 475	32 240	14 410	17 830	742	332	410	331	10.5	6.7	0.45
Australia	7 615	3 470	300	3 170	456	40	415	39	1.3	27.4	0.09
Europe	10 500	8 290	3 210	5 080	789	306	489	306	9.7	4.9	0.39
Oceania	1 335	3 610	2 090	1 520	2 700	1 560	1 140	1 566	51.0	287.0	0.58
The whole Land	149 000	119 000	47 000	72 000	800	315	485	315	10.0	12.9	—
Land without Antarctic and Arctic islands	135 000	116 000	44 000	72 000	859	326	533	326	10.3	12.2	0.38

* Population figures based on 1971 data (in all 3 600 million people)

part of the globe. Finland has, proportionally, the greatest area covered with swamps — 43 per cent of its territory, and Australia the least — only 0.5 per cent of the total area.

As shown in Table 7 [37], distribution of fresh water resources on our planet is very far from uniform. As regards Europe — the region of the highest concentration of productive forces — it makes up 7.56 per cent of the total river runoff, while in Asia it comprises 32.29 per cent.

Total water resources in the world's river beds are estimated at 2,115 cubic kilometres, and their distribution among the continents is as follows: South America — 47.3, Asia — 26.7, North America — 11.8, Africa — 9.2, Europe — 3.8, Australia and Oceania — 1.2 per cent. Principal rivers of the world are characterized by the following indices:

Length, km:

Nile (with Kagera)	6,670
Amazon (with Ucayali)	6,280
Mississippi (with Missouri)	5,985

Drainage area, thou. km³:

Amazon	6,915
Congo	3,820
Mississippi	3,220

Rate of flow

Amazon	220
Congo	44.9
Ganges (with Brahmaputra)	39.0

The world's greatest river, therefore, is the Amazon, since it leads the others in the extent of drainage area and the rate of flow, and is second in length.

Vegetation resources, or phytoplankton, are represented in the ocean by diatoms and drifting dinoflagellates — unicellular algae. There are several thousand forms of diatoms, each of which runs to innumerable millions of individuals. According to Lorree [38], they account for about 3/4 of the entire organic carbon annually produced by sea plants as a result of photosynthesis. Total annual productivity of all micro-

Table 8

World Fish and Shellfish Catches

Countries	Catch, t.		Countries	Catch, t.	
	1977	1978		1977	1978
Argentina	392,466	537,323	Mexiko	670,096	752,490
Bangladesh	835,000	640,000	Morocco	260,617	292,185
Brazil	748,487	857,971	Netherlands	313,044	324,436
Burma	518,700	540,500	Nigeria	504,024	518,567
Canada	1.270,027	1,406.757	Norway	3,460,013	2,647,074
Chile	1,398,958	1,698,484	Pakistan	269,958	293,029
China	4,700,000	4,600,000	Peru	2,540,675	3,364,843
Denmark	1,806,612	1,745,474	Philippines	1,510,789	1,558,383
Ecuador	475,500	475,500	Poland	654,828	571,397
Faeroe	310,281	318,142	Senegal	288,843	345,772
France	760,323	795,581	Spain	1,393,793	1,379,882
Federal Republic of Germany	432,089	411,918	Tanzania	261,025	287,150
			Thailand	2,189,907	2,264,000
Ghana	268,143	264,029	United States	3,085,211	3,511,719
United Kingdom	992,710	1,027,330	USSR	9,352,204	8,929,754
Iceland	1,378,182	1,579,019	Vietnam	1,013,500	1,013,500
India	2,311 869	2,367,852	World catch	71,212,900	72,379,500
Indonesia	1,571,852	1,655,000			
Japan	10,763,358	10,752,163			
Korea (North)	1,600,600	1,600.600			
Korea (South)	2,419,019	2,350,778			
Malaysia	499,148	565,995			

scopic oceanic plants reaches 15-20 thousand million tons [38].

Animal resources, or zooplankton, are represented by crustaceans, mollusks, fish, whales and many other species of sea animals. According to Riffault [39], the maximum annual quota of fish catch and other seafood output amounts to 200 million tons. The world fish catch, according to UN data, in 1976 was 71.7 million tons, in 1977 — 71.2, and in 1978 — 72.4 million tons. Statistics for individual countries are listed in Table 8. The highest results in fish catch and other seafood output are obtained by China, Japan and the USSR. Over the past few years, the assortment of fish being caught has more or less stabilized, yet there are substantial differences in the volume of individual species caught (Table 9). In 1978 the catch of certain fishes dropped as compared to 1976; pollack — by 23, Peruvian anchovy — by 72, mackerel — by 33.2, sprat — by 24.4, Pacific saury — by 38.9, European sardine — by 39.1 per cent. At the same time catches of poutasseau increased 4.4 times, Chile sardine — by 3.7, Chile hake — by 3.2, Chile jack mackerel by — 2.6 times etc. The most important fishing objectives are sardine, pollack, mackerel, capelin and anchovy.

Oceanic mineral resources have not been adequately studied and even tentative estimates are very approximate. The greatest contribution to the solution of this problem has been made in France by Cousteau, Le Prieur, Delauze, La Prairie, Riffault, Chouteau, Barthelemy and others.

According to Riffault's classification [39] mineral resources of the ocean can be dissolved in the water or be suspended in it. They are found as sediments consisting of fragmental products from

Table 9

Fish and Shellfish Catches Broken Down into Basic Species

Fishing target	Catches, t	
	1977	1978
Pollack	4,296,064	3,903,847
Capelin	4,008,745	3,157,258
Pacific mackerel	2,169,571	2,555,672
Atlantic cod	2,271,122	2,172,382
Pacific sardine	1,470,811	1,933,926
Chile sardine	1,491,709	1,855,348
Peruvian anchovy	810,775	1,183,880
Chile jack mackerel	848,071	1,014,457
Atlantic herring	990,402	935,954
European sardine	1,112,678	800,935
Striped tuna	634,032	791,786
Mackerel	687,953	718,059
Sprat	643,935	691,255
Cape anchovy	368,400	603,619
Cape jack mackerel	688,456	551,831
Poutasseau	251,017	550,735
Cape hake	597,697	519,517
Yellow-fin tuna	553,242	495,108
Chile hake	173,362	488,401
Pacific Saury	343,237	462,245
Saithe	545,386	459,141
Indian sardine	407,217	437,524
Pacific oyster	415,227	432,041
Esmark's cod	499,296	425,233

coastal beaches to deep-water plains (abyssal zones), including the continental shelf. Additionally, ore-bearing veins and beds as a continuation of land deposits may be found on the shelf, hidden under a layer of loose sediments. Oceanic mineral resources exist in volcanically active deep-water zones, in concretions of abyssal plains and may be of biological origin.

As a result of earth surface erosion 3300 million tons of solid matter annually find its way into the ocean. At least 4 million tons are sediments of cosmic origin [39].

Sea water abounds in mineral resources. It is a source of fresh water, deuterium, uranium, gold, sodium chlorine, bromine, magnesium, common salt, manganese, iron and lead. At the beginning of the 1970s, sodium, chlorine, magnesium (60 per cent of world output) and bromine (90 per cent of world output) were extracted from sea water for industrial purposes [39]. Considerable mineral resources are concentrated on the continental shelfoil, coal and iron ore, sulphur deposits, gas fields, sand and gravel. They all are of a continental origin, while phosphorites are formed by means of biochemical processes during sedimentation of substances dissolved in sea water.

Oceanic oil pools and gas fields have been found off the coasts of 30 countries. At present, sea deposits of only 24 countries account for nearly 16 per cent of the world output of oil and gas and for about 20 per cent of oil alone. Main oil-gas-producing areas include the Persian Gulf and the Gulf of Mexico, coasts of West Africa, Alaska, Australia, Indonesia, the Caspian Sea and the North Sea. The total number of oil and gas fields so far discovered is approximately 500, including over 300 in the United States water area, more than 30 in the North Sea, and 28 in the Persian Gulf. Of great interest to scientists and specialists in various branches of economy are uranium and radium deposits. According to preliminary data, the world's oceans contain more than 4 thousand million tons of uranium [40].

From the standpoint of economics, the deposits in polymetallic concretion of abyssal plains, whose volume is estimated to be 1500 thousand million tons (18), are reasonably promising. Concretions can be compared to a 'cocktail' consisting of manganese (26 per cent), copper, cobalt, nickel, iron, magnesium, aluminium, molybdenum, vanadium and other metals. The concretion deposits are mainly concentrated in the Pacific and to a much lesser degree in the Indian and Atlantic Oceans.

Additional Information

Many years may pass befare the mineral resources of the ocean can be effectively put at man's service. To speed up the development of these mineral resources, it is essential that geological, geophysical and geomorphological investigations should be continued, the ocean bed mapped systematically, detailed bathymetric maps of individual areas of the World Ocean compiled, soil samples gathered, magnetic and gravitational fields studied.

All these methods of exploring mineral resources of the World Ocean have become part and parcel of modern scientific practice and are constantly perfected, but the extensive exploration requires large numbers of highly skilled people, equipment and, above all, financial means. For the present, with few exceptions, prospecting for underwater ore deposits is financed quite inadequately, the sums ear-marked for it being much smaller than those for oil prospecting.

There is no denying the fact that exploitation of the ocean's wealth is the only way out of present difficulties when the demand for mineral products is steadily on the rise. However, mining companies still prefer to exploit mineral deposits on land.

Leaving aside all kinds of political and strategic considerations, we may say that this state of affairs is caused primarily by the high production costs of minerals extracted from the ocean. Only when prices of these mineral products become comparable with the prices of minerals obtained from the land, will the industry start investing heavily in the development of sea deposits.

Extraction of some minerals from the sea bed may already turn out to be profitable, but it has yet to be proved in practice [39].

Mineral Resources

Mineral resources — the basis of industrial development — are the total mass of useful mineral contained in the Earth's interior. They are classified as follows:

— power resources — oil, natural gas, fossil coal, combustible shale, peat, ores of uranium, etc.;

— ore resources — iron ore, manganese ore, chromites, bauxites, copper, lead-zinc, nickel, tungsten, molybdenum, tin, antimony ores, ores of noble metals, etc.

— mined chemical raw materials — phosphorites, apatites, common salt, potash and magnesium salts, sulphur and its compounds, barite, boric ores, solutions containing bromine and iodine, etc.;

— natural building materials and nonmetallic minerals — marble, granite, jasper, agate, rock crystal, garnet, corundum, diamond, etc,

— mineral water resources — underground fresh and mineralized waters.

In terms of quantity, mineral resources are determined by the extension of blocked-out and explored reserves of useful minerals. Statistics of the total reserves of mineral raw materials in the world for the 1970s (excluding the socialist countries) are given in Table 10. The picture of mineral reserves distribution among continents is as follows: Europe has 37.1 per cent of coal, 19 per cent of iron ore, 17 per cent of zinc and 28.6 per cent of potash salt. Asia accounts for 70.5 per cent of oil, 30.6 per cent of natural gas, 14.7 per cent of coal and nickel, 15.9 per cent of iron ore, 51.9 per cent of tin and 18 per cent of potash salt reserves. Africa possesses the largest uranium deposits (32.3 per cent), bauxites (40.2 per cent), copper (20.4 per cent), phosphorites (33.2 per cent). North

Table 10

Reserves of Major Useful Minerals in Continents, %

Minerals	Europe	Asia	Africa	North America	South America	Australia and Oceania
Oil	1.7	70.5	12.5	9.7	5.2	0.4
Natural gas	13.8	30.6	19.7	27.0	4.7	4.2
Coal	37.2	14.7	4.2	36.3	0.6	7.1
Uranium	6.4	0.7	32.2	37.8	0.9	12.0
Iron ore	19.0	15.9	9.3	23.1	21.2	11.5
Bauxites	3.0	4.1	40.2	12.2	9.3	31.2
Copper	2.4	7.2	20.4	39.6	27.0	3.4
Lead	17.0	5.6	6.0	50.2	7.1	14.1
Zinc	17.0	8.1	4.5	52.8	8.1	9.5
Nickel	2.7	14.7	2.6	21.5	3.1	55.4
Tin	5.2	51.9	10.9	1.4	24.9	5.7
Potash salt	23.6	18.2	—	58.2	—	—
Phosphorites	—	2.7	33.2	50.2	7.8	6.1

America is rich in natural gas (27 per cent), coal (36.3 per cent), uranium (47.8 per cent), iron ore (23.1 per cent), copper (39.6 per cent), lead (50.2 per cent), zinc (52.8 per cent) nickel (21.5 per cent), potash salt (58.2 per cent), and phosphorites (52.2 per cent). In South America reserves of iron ore account for 21.2 per cent, copper — 27 per cent, tin — 24.9 per cent. Australia and Oceania hold leading positions in reserves of bauxites (31.2 per cent) and nickel (55.4 per cent). Resources of major mineral raw materials in individual countries are given in Table 11.

The most considerable reserves of manganese ore have been discovered in Brazil, South Africa, India and Australia; chromites in South Africa, Zimbabwe, Turkey and in the Philippines; cobalt ore in Zaire, Zambia and Canada; tungsten ore in South Korea, Australia, Bolivia, Portugal, the United States and Brazil; molybdenum ore in the United States, Canada, Chile and Peru; mercury ore in Spain, Italy, Turkey, and Mexico; antimony ore in Bolivia, South Africa, Turkey, Thailand and Mexico; asbestos in Canada and Zimbabwe; potash salt in Canada, the Federal Republic of Germany, the United States and France; phosphorites in the United States, Morocco, Algeria, Tunisia, Peru and Australia; natural sulphur in Iran, Mexico, the United States, Jordan, Japan and Italy.

Resources of precious metals and diamonds can be judged by the output in 1977; gold (t) in South Africa over 910, Canada — 65, the United States — 44, Ghana and Australia — 23; silver (t) in Canada — about 1500, Peru — 1250, Mexico and the United States — 1160 each, Australia — 700; platinum metals (t): South Africa — about 42, Canada — 12.4; diamonds (million carats): in Zaire — 13.4, South Africa — 7.4, Ghana — 2.6, Botswana — 2.4, Angola — 2.2, Sierra Leone — 1.8, Namibia — 1.6.

Additional Information

Although a depletion of practically all known and accessible mining deposits is expected in the next few decades, potential reserves of compounds of nearly all chemical elements necessary for humanity are large enough and there is no serious threat of shortage. At the same there may be a shortage of such rare elements as silver, mercury, gold, platinum and helium, and this could create bottlenecks in the development of some important production processes and industrial flow charts. Another element which is absolutely indispensable and essential for human life is phosphorus — a key component of all mineral fertilizers. Though there is little reason to expect resious interruptions in supplies, it might perhaps be advisable to introduce certain measures controlling its consumption on a global scale so as to prevent its becoming a restrictive factor for the development

Table 11

Resources of Major Mineral Raw Materials in Countries

Countries	Resources
Oil, thou mill. t	
Saudi Arabia	18.7
Kuwait	11.2
Iran	8.9
United States	4.9
Libya	4.0
Iraq	3.9
Nigeria	2.0
Venezuela	1.9
Canada	1.4
Indonesia	1.4
Natural gas, billion m³	
United States	7.7
Iran	5.7
Algeria	4.7
Netherlands	2.5
Canada	1.6
Saudi Arabia	1.4
United Kingdom (incl. North Sea accumulation)	1.3
Nigeria	1.1
Australia	1.0
Bauxites, thou mill. t	
Guinea	1.2
Australia	1.1
Jamaica	0.3
Copper (metal in terms of ore), mill. t	
United States	69.0
Chile	46.0
Zambia	26.4
Zaire	20
Peru	20
Canada	17.7
Mexico	11.6
Australia	6.3
Philippines	6
Iran	5
Spain	3.8
India	2.5
Coal and brown coal, thou mill. t (explored reserves)	
United States	215
Federal Republic of Germany	133
United Kingdom	127
India	96
Canada	55
Australia	53
South Africa	25
Uranium (U_3O_8), thou t	
United States	300
Canada	214
South Africa	182
Australia	130
Namibia	90
France	41
Gabon	18
Algeria	12
Iron ore, thou mill. t	
Brazil	10
Canada	8.5
India	8.5
Australia	7
United States	5.5
France	4.5
United Kingdom	2.7
Sweden	2.4
Venezuela	2
South Africa	1.2
Lead and zinc (metal in terms of ore) mill. t	
United States	17 and 23
Canada	11 and 28
Australia	9 and 10
Mexico	4.1 and 6
Peru	2.8 and 5.8
Spain	3.4 and 5.4
Federal Republic of Germany	2.3 and 2.5
Sweden	2.3 and 2.4
Nickel (metal in terms of ore), mill. t	
Canada	8.8
Australia	5.2
Philippines	4.1
Indonesia	3.0
Greece	1.2
Tin (metal in terms of ore), thou t	
Malaysia	600
Indonesia	500
Bolivia	386
Brazil	300
Thailand	220
Australia	160
Nigeria	140
United Kingdom	130
Zaire	70
Lao People's Democratic Republic	60
Burma	50

of agricultural production. The need for such measures is made imperative by the fact that the rate of world consumption of phosphorus is nearly three times as high as that of the Earth's population growth.

Science and technology can play a key role in the solution of many problems related to the need for raw materials. Among them are economy of materials, miniaturization of equipment, the use of secondary raw materials, the development of new production processes, obtaining new materials, etc.

A problem of the utmost concern to all is that of energy. With fairly cheap,

effective, nonpolluting sources of energy, it would be relatively easy to find technical solutions to food and raw material problems. However, prospects for developing such sources are not very comforting: in the foreseeable future we can hardly count on wide use of methods for producing energy which would be both inexpensive and acceptable socially and economically. Furthermore, considering the usually long gap between scientific research and development to wide commercial application, there are no grounds to hope for new sources of energy: for another three or four decades at least, the world will have to depend for power mainly on mineral fuel, primarily oil and coal. Moreover, before mankind achieves virtually inexhaustible sources of energy, it is likely to live through periods of acute power shortage. Care will also have to be taken to preserve these kinds of mineral fuel for use elsewhere, in areas unrelated to energy production. This is why it is imperative that programmes be speedily implemented with a view to the gradual replacement of conventional sources of energy by some other power supply systems. Before there can be any hope of an improvement in the world's energy situation, therefore, we must be prepared for all kinds of difficulties and unforeseen complications.

In the near future, it will be unrealistic to count on any renewable or practically inexhaustible sources of energy; apart from the fact that extensive use of some of the might entail resious problems. The feasibility of producing energy through thermonuclear synthesis has not so far been proved; it is necessary to intensify research and development in this field, but it would be premature to regard it as a factor in any plans for the future. There is much scepticism about the practicability of extensive use of geothermal energy: this will largely depend on a successful solution of the problem of extracting heat from the Earth's crust. From an economic point of view, prospects for extensive use of solar energy to produce electric power heating would likewise seem dubious: progress in this field requires that a number of difficulties of a technical and technological character overcome. The only way to produce energy at the present level of scientific and technological knowledge and even here the prospect is a remote one — is atomic power engineering based on nuclear fission reaction. However, progress here is hindered by a number of problems of a social and environmental character, while some of the problems related to ensuring the safety of atomic power stations still defy solution. Some purely technical difficulties will have to be dealt with before breeder reactors can be introduced and used extensively.

The time has come for joint action by the whole of humanity since the energy problem is of a kind that requires the pooling of forces. The energy programmes of the world should be worked out with the participation of all groups and strata of the planet's population, with due regard for world public opinion. If the social and cultural aspects of these programmes are not carefully thought out, the miscalculations may be fatal for mankind, and the global nuclear experiment may have really disastrous effects.

Today humanity is at the crossroads: it has to choose ways for the further development of new sources of energy. This choice will in many respects shape our way of life and possibly our destiny for decades to come. That is why it is the duty of every political leader to reflect constantly, not only from the standpoint of his country, but as a matter of concern for all mankind, and to ponder the necessity and advisability of the nuclear approach. Perhaps on closer consideration it will be found that the development of solar energy

and its extensive use is a more reasonable course, even though it may have some disadvantages compared with nuclear engineering. Perhaps, guided by reason and a sober assessment of possible alternatives the world scientific community will give preference to a solar, rather than a nuclear society [40].

Terrestrial Resources

The total area of the world's land resources is 13,393 million hectares, which includes 1.457 million hectares of arable area (10.9 per cent), 2.987 million hectares of meadows and pastures (22.3 per cent); 4.041 million hectares of forest land (30.2 per cent) and 4.908 million hectares of other lands (36.6 per cent of all land resources of the planet). Table 12 [41] shows the land resources of individual countries and continents.

Of major importance to agriculture are arable (cultivated) lands which include pastures, laylands, and perennial plantations. The greater part of arable land — 841 million hectares, or 57.7 per cent of the total cultivated area — lies in Europe and Asia, including the USSR.

More than half of the world's resources of arable land — 745 million hectares — are concentrated in Brazil, Canada, China, India, the USSR and the United States. Compared with the last decade of the 19th century, the area of irrigated ploughlands increased 4.7 times and in 1972 was 188.3 million hectares, or 12.9 per cent of all cultivated lands. The largest areas of irrigated lands are in Asia (not including the USSR) — 70.3 per cent. China, India, the USSR and the United States taken together account for 131.3 million hectares of irrigated lands, or 69.9 per cent.

Meadows and pastures play a key role in the development of cattle-breeding. Good grasslands are found in Asia (not including the USSR) — 17.1 per cent; Australia and Oceania — 15.5 per cent; Africa — 27.5 per cent. 53.6 per cent of meadows and pastures are concentrated in Australia, Argentina, Brazil, China, Mongolia, the USSR and the United States. Pastures which include savannas, dry steppes, thin forests, tundra occupy a larger area than meadows.

Table 12

World's Land Resources, mil. hectares

Countries and continents	Total area (plowland + stable crops)	Including			
		arable area	meadows and pastures	forest land	other lands
USSR	2,240	233	375	910	722
Europe (not including USSR)	493	145	91	140	117
Asia (not including USSR)	2,753	463	511	542	1,237
North and Central America	2,242	271	362	824	785
South America	1,783	84	363	908	428
Africa	3,031	214	822	635	1,360
Australia and Oceania	851	47	463	82	259
Total:	13,393	1,457	2,987	4,041	4,908
Per cent of total:	100.0	10.9	22.3	30.2	36.6

Table 13

Land Available in Individual Countries (per capita, hectares)

Countries	Total area	Plowland
Europe		
Bulgaria	1.29	0.48
Czechoslovakia	0.88	0.36
Denmark	0.86	0.53
Finland	7.24	0.59
France	1,05	0.34
Federal Republic of Germany	0.42	0.13
German Democratic Republic	0.63	0.27
Hungary	0.89	0.50
Italy	0.55	0.18
Poland	0.94	0.45
Romania	1.14	0.47
Sweden	5.52	0.30
United Kingdom	0.44	0.13
USSR	9.01	0.90
Yugoslavia	1.23	0.36
Asia		
Afghanistan	3.62	0.44
China	1.20	0.14
India	0.58	0.29
Indonesia	1.89	0.15
Iran	5.39	0.53
Israel	0.64	0.10
Japan	0.35	0.05
Korea (North)	0.87	0.14
Mongolia	116.95	0.58
Pakistan	1.46	0.44
Thailand	1.34	0.25
Turkey	2.14	0.67
Vietnam	0.72	0.09
North and Central America		
Canada	46.61	2.05
Cuba	1.34	0.42
Mexico	3.75	0.43
USA	4.46	0.91
South America		
Argentina	11.61	1.00
Brazil	8.51	0.30
Chile	8.42	0.49
Columbia	5.06	0.23
Peru	8.88	0.19
Uruguay	6.00	0.64
Venezuela	8.31	0.42
Africa		
Algeria	15.60	0.41
Egypt	2.86	0.08
Ethiopia	4.71	0.51
Mali	23.57	2.20
Morocco	2.51	0.47
Nigeria	1.33	0.31
South Africa	5.31	0.50
Sudan	15.20	0.43
Uganda	2.26	0.36
Australia and Oceania		
Australia	59.31	1.52
New Zealand	9.26	0.28

Other land areas comprise populated areas, industrial areas, areas around roads, mountains and deserts, rocks, glaciers, marshes, dunes, Arctic tundra expanses, etc. According to FAO statistics, 200 million hectares of land can be considered potentially suitable for agricultural production. These areas are in Africa (70 million hectares), in Asia (not including the USSR and China) — 60 million hectares (in Iran — 33 and in India — 17 million hectares), in South America — 42 million hectares (in Brazil — 34 million hectares), in North and Central America — 30 million hectares (in the United States — 28 million hectares), in Europe (not including the USSR) — 6 million hectares.

Land resources per capita differ markedly from country to country and from continent to continent. In spite of the absence of a unified classification of the world's land resources, it should be noted that Australia and Oceania, by this index, hold a prominent place: the amount of land resources per

resident of the continent is 44.79 hectares of the total area, 2.47 hectares of the cultivated area, 24.38 hectares of meadows and pastures. The figures for the USSR are, respectively, 9.22, 0.94 and 1.54 hectares, for Europe (not including the USSR) — 1.07, 0.31 and 0.19 hectares; for Asia (not including the USSR) — 1.34, 0.22 and 0.25 hectares; for North and Central America — 7.00, 0.84, 1.12 hectares; for South America — 9.39, 0.44, 1.91 hectares; and for Africa — 8.91, 0.62 and 2.37 hectares.

Table 13 shows the land available in individual countries at the beginning of the 1970s.

On the whole, the land available per capita ranges from 0.35 hectares (Japan) to 116.95 hectares (Mongolia). Apart from availability of land, there are other important factors that should be taken into account: the country's economic potential, its population and area. All these factors considered, Australia presents an impressive picture — 59.31 hectares per capita. If this principle is applied to arable land, the figure for Japan will be 0.05 hectare, and for Canada 2.06 hectares per inhabitant. Among European countries prominent in this respect are the USSR (0.90 hectare), Finland (0.59 hectare) and Denmark (0.53 hectare); in Asia — Turkey (0.67 hectare), Mongolia (0.58 hectare) and Iran (0.53 hectare); in South America — Argentina (1.00 hectare) and Uruguay (0.64 hectare); in Africa — Mali (2.20 hectares), South Africa (0.50 hectare) and Ethiopia (0.51 hectare) [42].

Vegetation Resources

Measured in terms of dry matter, the Earth's vegetation annually produces 380 thousand million tons of biomass. The vegetation of the World Ocean accounts for 325 thousand million tons of organic matter, forests — for 38 thousand million tons, meadows, steppes — for 6 thousand million tons and other resources — for 11 thousand million tons. The following are the figures for plant species on the Earth:

	Number of species
Angiosperms (flowering plants)	150,000
Fungi	70,000
Mosses	15,000
Algae	14,000
Pteridophytes (ferns)	10,000
Liverworts	6,000
Gymnosperms	500

On the whole, the number of plant species on our planet ranges from 270,000 to 500,000. Only 90 species known to man are used as food, for cattle feeding and for technical purposes. Four-fifths of all vegetable substances are ploughed under or burnt, while only among flowering plants there are about 3,000 ebidle species. Of all this wealth 0.01 per cent of the increment of ocean biomass, 0.02 per cent of the increase of forest biomass and 0.03 per cent of biomass of meadows and steppes is used for food production [20].

Among vegetation resources a special place belongs to forest resources which comprise forest reserves, as well as food resources, game and fishery resources, fruits and berries of wild plants, mushrooms, medicinal herbs, etc. Forests cover 29 per cent of land, and their area is 3,772 million hectares (Table 14) [43].

Since the beginning of the 20th century the original area of forests has dramatically diminished. In the United Kingdom, for instance, it decreased by 95 per cent; in Italy, Greece, Spain, France, Belgium and the Netherlands — by 80 to 92 per cent; and in Finland and Sweden — by 44 to 50 per cent.

Several approaches have been adapted to problems of developing forest resources. In some cases, intact forest reserves may be incorporated in developed forests, in others the developed

Table 14

Area of World's Forests and Timber Reserves

Country and continent	[illegible] area, mill. hectares	Forest area, mill. hectares		Forest [illegible] %	Timber reserves, thou mill. m³	
		[illegible]	[illegible]		[illegible]	softwood included
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	39.5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

area is identified with the area of commercial felling, i. e. with the actual indices of wood utilization. As there is no generally accepted procedure for assessing developed forest reserves, each country has its own data in this field. (Table 15) [43]

The total area of nonproductive forests [illegible] about 1 [illegible] million hectares. These are forests with small and [illegible] timber reserves which are [illegible] commercially [illegible]. At the same time forest land with [illegible] for development total [illegible] million hectares in the USSR, 163 million hectares in North America, 157 [illegible] hectares in Latin America, [illegible] hectares in Asia [illegible].

Taibe 15

Tentative Data on Areas of Developed and Nonproductive Forests

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	709	423.0	56.0	109
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
North America	710	257	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	700	105.3	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible]

Area of Forests with Predominance of Softwood, mill. hectares

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	260	[illegible]
[illegible]	[illegible]	[illegible]	36	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	57	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	4	54	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 17

Average Reserves of Timber and Average Increment per 1 Hectare of Forest Land in Individual Countries

[illegible]	Average [illegible] per 1 hectare, m³			Average increment per 1 hectare, m³		
	[illegible]	[illegible]		[illegible]	[illegible]	
		[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.3	3.1
[illegible]	[illegible]	[illegible]	[illegible]	—	0.75	1.0
[illegible]	[illegible]	[illegible]	[illegible]	—	—	—
[illegible]	[illegible]	[illegible]	[illegible]	—	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0	2.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—
Federal Republic of Germany	[illegible]	[illegible]	[illegible]	[illegible]	3.7	5.0
German Democratic Republic	[illegible]	[illegible]	[illegible]	[illegible]	—	—
Hungary	[illegible]	[illegible]	[illegible]	[illegible]	3.3	3.9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.0	3.4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.4	1.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.6	2.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0	1.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.8	2.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.9	2.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.11
[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.61	2.61
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.09	1.75
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.3	2.5

[illegible] composition of forest [illegible] zed by the correlation between coniferous and nonconiferous forests, the tentative indices of which [illegible] Table 16 [43].

The condition [illegible] productivity are largely [illegible] the average timber [illegible] [44].

Resources of the Animal Kingdom

About 1.5 million animal species existing in the world are known. Scien- [illegible] archeocytes, coelenterates, seg- [illegible] lows [20]:

	Number of species
Arthropods	815,000
including insects	750,000
Mollusks	88,000
Vertebrates	35,000
including fishes	18,000
birds	8,600
reptiles and amphibians	5,500
mammals	3,500
Worms and vermicular	25,000
Protozoans	15,000
Coelenterates and ctenophorans	10,000
Sponges	5,000
Echinoderms	4,700
Tunicates and protochordates	1,700

The geographic zoning of territories taking account of climatic features of the continents, distribution of vegetation and other factors makes it possible to single out the most widely distributed representatives of the animal kingdom in the different continents.

Europe. The European tundra shows little variety as to species on account of the severe climate and a shortage of feed vegetation. Characteristic species are small rodents (Siberian and Arctic lemmings, Middendorf field bouse), reindeer, Arctic fox, wolf, seals (bristly seal, bearded seal). The musk ox brought from Greenland has become acclimated in Spitsbergen. Birds are represented by ptarmigan, snowy owl and, on the sea coast, by sea gull, cormorant, goose, eider, guillemot, etc. Owing to large amounts of food resources, the species composition of taiga animals is much more varied. Mammals of this zone are represented by wood mice, chipmunks, wood lemmings, squirrels, flying squirrels, blue hares, sables, gluttons, ermines, weasels, brown bears, wolves, fox, elks; birds included are wood grouse, hazel grouse, nutcrackers, barred owls, tits, crossbills, bullfinches, waxwings, hawks, etc. Blood-sucking insects are very numerous.

Among the animals found in broad-leaved and mixed forests, especially in Western Europe, may be mentioned — minks, polecats, European wild cats, red deer, roe deer, wild boar, bats, hedehogs; and some animals are also found in the taiga — brown bear, foxes, wolves, martens, badgers, elks, European bison, etc. Broad-leaved forests are a habitat of green and middle woodpeckers, woodcocks, cuckoos, jays, chaffinches, nightingales, heath cock, owls, doves, orioles, thrushes, tits; in some West-European countries acclimated pheasants are now widely distributed.

The destruction of forests and the emergence of vast open expanses led to the appearance in this region of certain steppe animals, including common hamsters and field mice, bustards, gray partridges, and quail. The number of forest inhabitants has sharply dwindled and large mammals are particularly scarce. The tur disappeared in Western Europe in the first half of the 17th century as a result of changes in the ecological systems related to various economic activities of the population. In the Balkan Peninsula, lions suffered the same fate and the number of wolves dropped sharply.

Birds also suffered: ibis is extinct and the number of eagles has diminished considerably.

The steppes and semideserts of Europe are inhabited by various rodents (gophers, hares, marmots, great jerboas, mole rats, northern mole voles, field mice) and by European hares, steppe polecats and foxes; water bodies are the habitat of water voles and otters. Among birds there is a large group of birds of prey: harriers, kestrels, imperial eagles. Larks, quail, gray partridges, bustards and little bustards are also found. Flooded areas around big rivers are alive with numerous pochards, ducks, herons, cormorants and sandpipers.

The Mediterranean mammals include: Alpine ibex and wild goats, cha-

mois, mouflons, Pyrenean desman, genettes, Europe's only monkey, the Barbary ape (Gibraltar), porcupines and jackals. Birds include: lammergeier, Pyrenean and rock sparrows, choughs, Eastern blue magpies, swifts, swallows, warblers, wall creepers, while reptiles include: lizards, geckoes, glass snakes, adders, grass snakes, wood snakes, tortoises and among the amphibians are frogs, toads, salamanders, blind white salamanders, newts; and among the insects, cicadas, butterflies, mosquitoes, etc.

Asia. The fauna of this continent is characterized by pronounced continentality. A distinctive feature is the large number of animal families adapted to various living conditions. The number of groups of a high taxonomic rank endemic to Asia alone is relatively small. Only one order of mammals (flying lemurs) with two species and four families (tree shrews, tarsiers, gibbons and giant bears) is endemic.

The area of the northern oceanic coast and Asiatic tundra are known for their scanty fauna. Neither reptiles, nor amphibians occur in this zone. Almost all the birds are migratory. The range of animals in the tundra is especially meagre, consisting of reindeer and Arctic fox, shrews and voles. Typical birds are:

Arctic falcon, snowy owl, ptarmigan and whillow grouse, several species of sparrow, ducks, swans, geese; the sea coast fauna is represented by seal, walrus, polar bears and birds such as the eider, seagull and guillemot.

The inhabitants of the Asian taiga include mammals — elk, deer, roe deer, brown bears, gluttons, lynx, sables, blue hares, squirrels, etc.; birds: woodpeckers, thrushes, owls, sparrows, heath cocks, hazel grouse, wood grouse, etc.; reptiles — lizard, adder, Ussurian mammushi. There are sturgeon in the rivers. The composition of insects is diverse.

Characteristic of the steppes, deserts and semideserts are: mammals — antelopes (Persian gazelle, saiga), Prjewalski horse, wild Bacterian camels, wild sheep and goats, tigers, lions, panthers, leopards, small cats, striped hyenas, jackals, large numbers of rodents and other species; birds — larks, desert jays, bustards, sand grouse, demoiselle cranes, certain species of sandpipers and birds of prey (vultures, saker falcons, griffons), pheasants, mountain partridges, etc.: reptiles — various lizards, snakes, adders, cobras, wood snakers. There are several tortoise species. The number of amphibians is small. Invertebrates include orthopterous insects (grass-hopper, locusts), scorpions, solifuga, etc. In the European-type forests (Islamic Republic of Iran) there occur peculiar forms of deer, roe deer, bear, lynx and other animals.

The Central Asian highlands are the habitat of antelopes (ada and Tibetan), special subspecies of wild sheep, mountain goats, white-heated deer, a peculiar species of kiang, Tibetan subspecies of brown bears, wolves, foxes, red wolves, snow-leopard, rodents. There are not many birds in those areas. Among them are bar-headed geese, griffon, lammergeier, choughs, snow-cock, etc. Reptiles and amphibians are very scanty.

The animals characteristic of the zone of broad-leaved and subtropical forests of Eastern Asia include several species of deer, mountain hoofed animals related to antelopes, local subspecies of boar, raccoon dog, giant panda, mouflon, tiger, Asiatic black bear, large numbers of rodents, several species of monkeys and apes. There is much variety among the birds. Numerous reptiles are represented mainly by the Indian and Malay genera of lizards and snakes. It should be noted that leatherback turtles and alligators also occur in this region. Amphibians include tree

frogs, giant salamanders, etc. There are a large number of insect species. The Primorye Territory of the USSR is the habitat of relict barbel.

Typical animals of the continental part of the South Asian tropical forest zone are: Indian elephant, three species of rhinoceros, several species of ox, deer, wild boar, antelopes, martens, otters, bear, tigers, panthers, rodents, bats.

There are several species of the family of gibbons and orangutans. River dolphins are to be found in some of the rivers.

There are countless numbers of bird and reptile species, and a considerable quantity of amphibians.

North America. The fauna characteristic of the tundra zone includes: caribou, polar bears, Arctic foxes, lemmings, blue hares, snowy owls, willow grouse and the musk ox which is to be found only in the North of the Canadian Arctic archipelago and in Greenland. The most typical representatives of the taiga are: elk, deer, pine martens, brown bears, Northern lynxes, gluttons, beavers, porcupines, muskrats, black foxes, red squirrels. The number of animals, especially fur-bearing varieties, has sharply decreased. An even more marked decline has occurred among the fauna of mixed and broadleaved forests which included a number of unique species. Some representatives of tropical fauna occur in the subtropics, in the south-east of the continent: alligators, snapping turtles, ibis, flamingo, pelicans, hummingbirds, Garolina parrakeets. Prairy animals have been decimated by man: among those that have suffered are bison, antelope, pronghorn, prairie fox. There are many rodents: polects, badgers, etc. The mountain and wood landscapes of the Cordillera are the habitat of bighorn sheep, grizzly bears (in Alaska) and mountain goats. The deserts and prairies swarm with reptiles, some of them poisonous (rattlesnakes and beaded lizards), constricting snakes, etc. In Central America, the West Indies and, to some extent, in the south of the Mexican high plateau, there are large numbers of tropical animals, including representatives of South American fauna: armadillos, monkeys, bats, hummingbirds, parrots, turtles, crocodiles, lizards, etc.

South America. A characteristic feature of the neotropics is the existence of some endemic groups of animals: mammals — the Edentata order (families of sloths, anteaters and armadillos), groups of New World monkeys, several rodent families, vampires (from the Chiroptera order), llamas, some marsupials: several bird orders; certain reptiles, amphibians, fishes and invertebrates. Conversely, there are not many even-toed ungulates, almost no insectivores, no Old World Monkeys, etc. Most widely represented is the animal kingdom of the equatorial and tropical rain forests. Numerous animals have prehensile tails, there are a large number of felines, including jaguar and ocelot. The avi-fauna is of a variety. The same applies to the reptiles, tree amphibians and, notably, insects. There are several arboreal ant species. The most typical of the arachnids are bird-eating spiders. Conspicous among animals living on the ground are giant armadillos, great anteaters, peccaries, tapirs, coatis, bush dogs, and rodents. The numerous water bodies are inhabited by manatee, river dolphin, endemic anaconda, caiman, lung fish, electric eel, etc.

The animals predominating in the subequatorial and tropical savannas and thin forests are: armadillo, small deer; carnivores — puma, savanna fox; rodents, rhea (nandu). In the deserts of the south the most typical are endemic rodents and nonflying birds; carnivorous animals — pampas cat, puma, etc.

Central America. So far as its fauna is concerned, Central America is part of the neotropical zoogeographical region. Its animal kingdom includes New World monkeys, peccaries, tapirs, armadillos, jaguars, vampire bats, and numerous birds, reptiles and insects. In the northern part of Central America the most typical are representatives of North America: lynx, raccoons, many rodents (gophers, hares, squirrels, common shrews, bandicoots, etc.). There are a number of endemic species among the tapirs, rodents, bats and birds.

Oceania. The greatest part of Oceania belongs to the Polynesian faunistic region with the subregion of the Hawaiian Islands.

The fauna of New Zealand is now considered to be a separate region, while that of New Guinea is included in the Papuan subregion of the Australian region.

Chapter III

FUNDAMENTAL PROBLEMS OF THE MAN-ENVIRONMENT INTERACTION

MAN AND ECOLOGICAL BALANCE

Social Production and Living Standards

In its relationships with the environment as a whole, mankind strives to raise its living standards which are determined by the degree to which material, social and spiritual needs are satisfied.

Proceeding from the principles of geographical zoning of the territory and basing their survey on economic management systems, the gross national product (GNP) indices, and the share of manufacturing industry in the GNP, a group of United Nations experts headed by Leontiev has suggested the following classifications in respect of 171 states (estimated population figures as of 1970; per capita income in United States dollars at the official 1970 exchange rate).

1. North America — population: 229.1 million; income per capita — $ 4,625.
2. Latin America — medium income — population: 191.4 million; income per capita — $ 594.
3. Latin America — low income — population: 90 million; income per capita — $ 443.
4. Europe — high income — population: 282 million: income per capita — $ 2,574.
5. Europe — medium income — population: 108.1 million; income per capita — $ 698.
6. The Soviet Union — population: 242.6 million; income per capita — $ 1.791.
7. Eastern Europe — population: 105.1 million; income per capita — $ 1,564.
8. Asia with centralized economy planning — population: 808.4 million; income per capita — $ 167.
9. Asia — high income — population: 104.3 million; income per capita — $ 1,916.
10. Asia — low income — population: 1,023.2 million; income per capita — $ 121.
11. Middle East — Africa — oil producing countries — population: 126,5 million; income per capita — $ 286.
12. Africa arid — population: 131.2 million; income per capita — $ 205.
13. Africa tropical — population: 141.4 million; income per capita — $ 168.
14. Southern Africa — medium income — population: 21.5 million; income per capita — $ 786.
15. Oceania, Australia, New Zealand — population: 15.4 million; income per capita — $ 2,799.

Table 18

Gross National Product per Capita in Various Countries of the World (Dollars)

Country	1974
Socialist countries *	
Bulgaria	1,770
Czechoslovakia	3,220
German Democratic Republic	3,430
Hungary	2,140
Poland	2,450
Romania	1,700
USSR	2,300
Countries of Western Europe, United States and Japan	
Austria	4,050
Belgium	5,210
Denmark	5,820
Finland	4,130
France	5,190
Federal Republic of Germany	5,890
Greece	1,970
Holland	4,880
Iceland	5,550
Ireland	2,370
Italy	2,770
Japan	3,380
Luxemburg	5,690
Norway	5,280
Portugal	1,540
Spain	1,960
Sweden	6,720
Switzerland	7,340
United Kingdom	3,360
United States	6,640
Countries of Latin America	
Argentina	1,900
Bolivia	250
Chile	820
Dominican Republic	590
Ecuador	460
El Salvador	390
Haiti	140
Honduras	340
Mexico	1,000
Panama	1,010
Paraguay	480
Peru	710
Trinidad and Tobago	1,490
Uruguay	1,060
Venezuela	1,710
Countries of North Africa	
Algeria	650
Libyan Arab Jamahiriya	3,360
Morocco	430
Sudan	150
Tunisia	550
Countries of Equatorial and Southern Africa	
Ethiopia	90
Gabon	1,560
Ghana	350
Ivory Coast	420
Kenya	200
Liberia	330
Madagascar	400
Malawi	130
Mali	70
Nigeria	240
Senegal	320
Uganda	160
United Republic of Tanzania	140
Zambia	480
Countries of South and South-East Asia	
Malaysia	660
Philippines	310
Sri Lanka	130
Thailand	300
Countries of Middle East	
Islamic Republic of Iran	1,060
Iraq	970
Jordan	400
Kuwait	11,640
Lebanon	1,080
Saudi Arabia	2,080
Syrian Arab Republic	490
Turkey	690

* Volume of national income per capita

As can be seen, there is a wide gap in economic development and levels of income throughout the world. In the countries where 73 per cent of the planet's population reside, the annual income per capita ranges from $ 121 to 786, while in the states numbering 27 per cent of the Earth's inhabitants it ranges from $ 1,791 to 4,625.

It should be noted that the averaged indices somewhat conceal the extent of the gap and striking disproportions in the development of world economy. A true picture can be obtained by comparing the absolute GNP data of individual countries listed in Table 18 [45].

Extending the use of environmental resources for producing material wealth will help to eliminate the unevenness of economic development. Here questions arise on the adequacy of natural resources to support a rate of economic development that would narrow the discrepancy between the quality of life enjoyed in different countries.

Technological Progress and Environmental Problems Modification

If the basic principles of the proposed new economic order were implemented and its sphere of influence expanded in the world, the channeling of additional natural resources into production would become an indispensable condition of eliminating the enormous difference in the life standards between countries. Countries should take into account previous experience and remember the lessons of history in the field of environmental control if they are to avoid wasting labour, time and means in trying — perhaps too late — to eliminate the adverse effects of tampering with the ecological system.

This problem should be considered together with all factors of development, without an artificial singling out

of certain ad hoc measures ensuring major incentives of modern economic activities — a drive for maximum production, a desire for quick profits and a rapid turnover of capital investments — which create situations opposed to the rational use of all material resources possessed [33].

The importance of this problem, both in theoretical and practical aspects, is growing: the characteristic feature of the second half of the 20th century, particularly of the 1980s and 1990s, will be the co-existence of new machines and technology with the traditional technical basis of the 1940s and 1950s, with a predominance of the latter, partially renovated. It is quite likely that the year 2000 will see the beginning of a new stage in which machinery and technology based on most advanced ideas in science and engineering will be able to assume a predominant position in major sectors engaged in creating GNP.

This feature of long-term development of material production is accounted for by the existing disparities in the realization and implementation (in production) of scientific achievements. Basic characteristics of this stage are largely determined by the enormous sluggishness of the existing production apparatus. A considerable proportion of the operational production equipment is still geared to the output of traditional machinery, thus ensuring its future economic importance. Furthermore, there is a substantial time disparity between stages of scientific and technological progress — from a scientific hypothesis to a scientific discovery and to the introduction of its results into the productive sphere. Another relevant factor is the duration of construction, erection and commissioning of various industrial projects. The ever-growing environmental pollution will affect human organisms and living nature.

The solution to various problems of nature conservation and environmental control depends largely on a fundamental reassessment and restructuring of production techniques for obtaining all kinds of industrial products which, in conjunction with biological, physiological, economic, technical and hygienic disciplines, would effectively contribute to a fuller satisfaction of man's requirements with due regard for:

— harmonious interaction between society and nature under conditions of rapid scientific and technological progress and steadily accelerating growth of the planet's population;

— raising the efficiency of exploitation of natural resources;

— preservation and improvement of nature's potential in the interest of present and future generations;

— reliable and timely predictions of ecological processes and the effects which economic activities will have upon them.

Given that the perfection of technology plays the crucial role in lowering the pollution level, the requirements listed below should be regarded as guidelines for environmental protection technology in various sectors of the economy. The requirements are as follows: phasing out or sharp reduction of the discharge of industrial, agricultural and other wastes into the environment through the development and implementation of effective methods of burning fuels, low-waste, waste-free and closed-cycle production processes and complete processing of raw materials and recycling of waste; rationalization of water consumption in industry, agriculture and public utility services; overcoming water shortages in areas suffering from inadequate water supply on the basis of the existing facilities, without tampering with various ecosystems; and preservation, restoration and extension of areas of productive land while increasing harvests both in old and newly cultivated lands; preventing the exten-

sion of farmland at the expense of national parks and forests.

These requirements make it possible to establish more accurately technological measures aimed at bringing under control the discharges of various chemical compounds into the environment. Each industry faces tasks of its own. For example, industries such as chemical and petroleum refining, chemical and oil machine building and nonferrous metallurgy face the task of developing and operating new types of equipment, devices and chemical agents for treating sewage. Highly efficient gas and water treatment facilities and monitoring devices are generally required. Ferrous metallurgy, steel, cement and other industries must use modernized dust-trapping equipment to ensure the minimal discharge of valuable elements and substances into the atmosphere, rather than merely maintaining established amounts of effluents. Mining industries should introduce new technological facilities ensuring the maximum use of both essential minerals and also other useful minerals extracted with them. This applies to all kinds of mineral raw material processing.

In view of great losses of minerals in the interior of the Earth, the search for effective ways and methods of extracting them is gaining in importance. Losses of minerals can largely be attributed to inadequate methods of working the deposit and unsatisfactory mining technology.

Huge internal reserves can be brought into the economy by implementing measures for maximum extraction and utilization of all valuable components contained in minerals. The problem will depend on the country's (or region's) need for particular mineral raw materials, and its solution — on the scientific and technological potential.

The complex exploitation of mineral resources has a substantial economic effect, including the reduction of mineral losses and the corresponding expansion of raw material reserves, the improvement of the technical and economic indices of industry, the improvement of the environment on the whole and land use in particular.

Of special importance is recycling of waste from ore dressing plants, metallurgical works and other industrial enterprises. Outside big plants of ferrous and nonferrous industry there are huge heaps of slag which build up rapidly every year and run into hundreds of millions of tons. Outside certain thermal power stations there are large amounts of cinder and ashes left after the burning of coal. Metallurgical slag can be used as raw material for obtaining both essential and associated valuable components as well as for producing various building materials and mineral fertilizers.

Raising the degree of utilizing natural raw materials and diversifying their uses has become an important element of rational conservation. The widespread method of protecting the environment (air, water, soil) against pollution with industrial waste by means of purification in many cases complicates technological processes and involves additional capital investments.

That is why it is so important to work out carefully fundamentals of technology, designing and building of industrial enterprises with waste-free processes, whereby all the raw materials delivered are used up.

A complex utilization of mineral resources, a sharp reduction in the amount of mineral material used per unit of output and the expansion of raw material reserves (with due regard for the improvement of the environmental condition) require further improvement of cinder-and-ash processing technology; a wider application of methods of heat treatment of coal dressing waste to obtain materials that can be used in other production spheres; and the de-

velopment of techniques for storing and utilizing waste from the metallurgical industry, thermal power stations, farm produce processing plants, etc. to obtain additional products, reduce the area set aside for waste, and use nonrecyclable solid waste.

Solution of the problems described above is of immediate importance to countries throughout the world.

Secondary utilization of raw materials not only alleviates mineral shortage and saves energy, water and natural resources; it also effectively lowers pollution levels (see Table 19) [47].

The prognostication **Resources for the Future** prepared by an American private research corporation shows how the level of environmental pollution depends on the condition of the technological structure of production. The prognostic data for the period up to the year 2000 indicates that the degree of pollution during this period, instead of declining, may grow considerably if the present technological structure remains unchanged. Conversely, the restructuring of traditional production process, the speeding up of development and implementation of waste-free (above all nontoxic and waterless) technological processes, even with the maximal increase in gross national product and population, would ensure that the pollution level does not exceed the 1970 figure.

Table 19

Benefits from Replacement of Primary Raw Materials with Secondary in the Production of Certain Materials, %, (calculated on 1000 t of finished product)

Index	Steel (100 % of scrap iron)	Glass (60% of cullet)	Paper (100 % of waste paper)
Reduction:			
air pollution	86	6-22	73
water pollution	76	—	25-44
pollution with solid waste	97	70	39
Saving:			
energy	74	6	70
water	40	50	61
natural resources	90	54	100

As low-waste and waste-free technologies and resource recovery programmes continue to gain ground, the environmental problems tend to become socio-economic problems of development that should be tackled taking account of specific features of the national economy, policy and living standard.

Armaments Race and Irrational Use of Natural Resources

It is common knowledge that wars, arms races and cold war are most detrimental to the environment. At the present stage in the development of science and technology, they invariably have pernicious effects on many components of ecosystems which are vital for man's existence. Sometimes that damage is irreparable.

Modern warfare, even without the use of nuclear weapons, does incalculable damage to the environment, and the never-ending arms race is the greatest potential source of developing and producing means of a large-scale ecological war which will be capable of causing floods, earthquakes, hurricanes, catastrophic changes of the climate with consequences hard to predict.

The arms race results in wasting astronomical sums of money — and this at a time when money is so badly needed to improve the quality of life of many millions of people. In the USA, for example, the military budget for the 1981/82 fiscal year amounted to $ 713.6 per capita, more than the gross domestic product (GDP) per capita in

such countries as Bolivia, Ecuador, El Salvador, Haiti, Honduras, Jordan, Peru, the Philippines, Sri Lanka, the Syrian Arab Republic, Turkey, etc.

At the same time, 24 million people in the United States live below the officially established 'poverty level'.

The new round of the arms race and the production of weapons of mass destruction stultify efforts of progressive people in many countries of the world to ensure a lasting peace on our planet. Nuclear weapons, as all other types of modern weaponry, are inhuman means of ecological war which may lead to an ecological catastrophe and jeopardize the biological and geochemical foundations of life on the Earth. They only swell the military budget, lead to an irrational use of natural resources and ensure a stable growth of military machines and for profits for companies and monopolies having a vested interest in its production. That is why the struggle against the threat of nuclear war, against the military build-up is at the same time the struggle for the conservation of the environment.

Control of Environmental Pollution

The environmental pollution level all over the world continues to rise as a result of the growth in the volume of industrial production. Annually 100,000 million tons of various ores, fuels and building materials are extracted, 50 million tons of synthetic goods are manufactured, nearly 92 million tons of mineral fertilizers and more than 2 million tons of various toxic chemicals are sprayed in the fields. The Earth's atmosphere receives more than 200 million tons of carbon monoxide, more than 50 million tons of various hydrocarbons, approximately 146 million tons of sulphur dioxide, 53 million tons of nitrogen oxide and many other pollutants. Power plants alone send into the atmosphere more than 200 million tons of ashes and nearly 60 million tons of sulphur dioxide. Each year, industry fills the environment with unpurified water (32,000 million cubic metres), dust (250 million tons) and toxic gases (70 million tons). Rubbish tips and garbage dumps grow together with technological advances. Industrial and domestic waste in the cities amounts to nearly 3,000 million tons annually.

One of the major sources of air pollution is exhaust of motor vehicles which eject into the atmosphere over 200 million tons of carbon monoxide and approximately 50 million tons of various hydrocarbons. In the United States, according to the statistics of the National Academy of Sciences, every year 4,000 people succumb to the toxic effects of exhaust gas, and the damage to various branches of economy caused by pollution-induced diseases is assessed at $ 16,000 million, or $ 80 per capita annually.

A beginning of world-wide co-operation in the fields of environmental control was made by the Stockholm United Nations Conference of 1972. At present a special place is held by UNEP. A project has also been worked out — the Global Environmental Monitoring System (GEMS). It has a more specific character and deals mainly with methods and technical facilities for monitoring the environment which cover the major parameters of its protection.

Several international organizations — OECD, CMEA, EEC, FAO, UNDP, the World Health Organization (WHO), WMO and UNESCO pay considerable attention to the global monitoring and control of the environment. This is also true of the Scientific Committee on Problems of the Environment (SCOPE), under ICSU, the International Commission for the Protection of the Environment Against Carcinogenic and Mutagenic Substances (ICREMS), the International Academy for Environmental Security (IAES), the Interna-

tional Society for Ecotoxicology (SECOTOX) and other non-governmental organizations and associations. OECD works out recommendations listing requirements for expert examination of toxic agents as well as a special programme for chemicals control aimed at setting up an international system of control over toxic substances. A special OECD programme studies the possibilities of using various species of plants and animals as indicators of the level of the environment's pollution with toxic agents.

Nevertheless, the international aspects of monitoring the environmental pollution are still in the making. Sometimes the acceptance of international standards conflicts with the national interest of certain countries, encounters great financial difficulties arising from both lack of agreement on the size of investments in programmes and the attempts by industrial companies and corporations to maintain their profit levels. Great efforts will have to be made before general principles of classifying pollutants are worked out and international standards in the field of monitoring environmental pollution are established and universally accepted.

The principal form of control of environmental pollution is legislation on the protection of air, water, soil, fauna, flora and other components of nature. On the basis of laws regulating relationships of the economy with the environment, a system of ecological standards is established with administrative and economic measures to ensure their maintenance.

The rules which follow contain general requirements for working out standards to be established for individual components of the environment.

The maximum permissible emission of effluents into the atmosphere should be established for every source of pollution, with the proviso that effluents from this source and from other sources in the city (or in another populated area) do not produce a surface concentration exceeding their maximum allowable concentrations (MAC) for the population, plants and animals. When establishing the maximum permissible exhaust, it is important to take into account prospects of industrial development and the dispersion of harmful substances in the atmosphere. The maximum permissible emission (MPE) — a quantity of effluents which is not to be exceeded while being released into the atmosphere during a specified unit of time — is determined on the basis of calculating MPE into the atmosphere.

If concentration of harmful substances in the air of cities or other localities exceed MAC, and the values of MPE, for reasons of objective character, cannot be attained at the present, a stage-by-stage reduction of exhaust emission from operating plants and factories must be introduced and remains in effect until values are reached which ensure the observance of MAC or until the exhaust emission is phased out.

At each stage, until MPE values are attained, it is necessary to establish, as an interim measure, a provisionally agreed-on emission (PAE) at the level of the emission from similar industrial enterprises with more advanced production techniques.

When establishing MPE and PAE, provision should be made for eventual industrial development; physicogeographical and climatic conditions and the location of industrial sites and residential and recreational areas should be also taken into consideration.

To prevent or effectively reduce organized (or nonorganized) discharge of hazardous industrial waste, advanced modern technology, purification methods and facilities should be used, in conformity with health regulations for industrial enterprises.

The dispersion of harmful substances in the atmosphere by way of in-

creasing the height of their emission can only be resorted to after all available modern facilities have been used to reduce the exhaust emission. When it is impossible to eliminate or effectively reduce the exhaust emission from certain plants and factories, measures should be taken to move them beyond the city boundary, change the character of production in these industrial enterprises or create sanitary protection zones around them.

Reduction of soil pollution envisages the raising of soil fertility through the establishment of standards and quality criteria and the implementation of measures aimed at protecting soils from erosion, salinization or swamping. It is also important that land be set aside for agriculture in accordance with a carefully-planned land redistribution and transformation policy. Land improvement should become more efficient; unique natural objects and their ecosystems should be preserved as national property; landscaping must be based in part on biological and production factors, which implies the establishment of standards.

Bodies of water are considered to be polluted if the indices of composition and properties of the water in them have changed due to the human activities, rendering them partly or completely unfit for one of the uses to which water is put.

The water pollution criteria are: deterioration of its quality due to changes in its organoleptic properties and the appearance of substances harmful for man, animals, birds, fish and food organisms. A rise in water temperature changes conditions for normal vital functions of water organisms. When determining conditions of effluent discharge in cases of the simultaneous use of a water body for various needs, it is advisable to adhere to rigid norms from a series of quality standards for surface water.

Bodies of water should be protected against leakage from oil and all-product pipelines of oil fields as well as against the discharge of unpurified sewage, and bilge and ballast waters and other substances from ships. Discharge of the following into bodies of water should be forbidden: industrial liquid waste that can be eliminated by the implementation of rational technology, by use in the recirculating water supply system or by introducing drainless production; sewage containing valuable recoverable waste; waste water containing production raw materials, reagents, semiproducts and end products in qualities exceeding the existing norms of technological losses; sewage containing substances for which MAC has not been established; sewage that can be used — if its composition and if conditions permit it — for irrigation, provided sanitary requirements are duly met. Sewage discharge into water bodies located in national parks should be banned.

While determining conditions of sewage discharge into bodies of water, account should be taken of the extent of possible mixing and of dilution of sewage between the place of discharge to the control gates of the closest water works or fish-rearing station and of the quality of water in reservoirs and streams upstream the place of planned sewage discharge.

The system of ecological standards is supplemented by surveillance facilities, taxation, fines, payments for using certain types of resources, etc. Surveillance facilities include automatic stations and pollution monitoring systems; fixed and mobile automatic installations and gas analyzers; laser systems for remote air pollution analysis; spectral devices; gas and liquid chromatographs; samplers; means of metrological support of devices. There is a considerable quantity of sophisticated equipment including devices for automatic monitoring of

the condition of air, sewage and surface waters. They are noted for high sensitivity, accuracy and speed in obtaining required indices. These measuring instruments incorporate complicated electronic systems for information collection, transmission, storage and processing.

USE OF THE ATMOSPHERE AND ITS POLLUTION

Composition of the Atmosphere

The atmosphere is a gaseous mass enveloping the Earth and rotating together with it. The mass of the atmosphere amounts to 5.15×10^{15} tons. No life can exist on the Earth without the atmosphere: oxygen is required by living organisms for respiration and carbon dioxide is necessary for plant nutrition. The atmosphere is subdivided into troposphere, tropopause, stratosphere, stratopause, mesosphere, mesopause, thermosphere and exosphere layers (see Fig. 5).

The troposphere is the lowest atmospheric layer where temperature decreases with height. In polar latitudes, the troposphere is 8 to 10 km high; this increases to 16 to 18 km near the equator. Since the density of air rapidly decreases with height, the troposphere's share in the entire mass of the atmosphere is up to 80 per cent. The transition layer between the troposphere and stratosphere is formed by the tropopause. The stratosphere in its turn consists of a lower part where, at the height of 25 km, the temperature remains approximately constant and an upper part where it starts to rise. Within the mesosphere at 55 to 80 km, further temperature drop is observed. The mesopause is situated between the mesosphere and thermosphere. The exosphere is at a height of 1000 km and more, therefrom atmospheric gases dissipate into the space and a gradual transition from the atmosphere to outer space takes place.

General circulation of the atmosphere creates specific climatic conditions and affects the water cycle. Atmosphere is the main sound transmitter and protection from the destructive properties of ultro-violet radiation. The chemical composition of dry atmospheric air is as follows (in percentages); nitrogen — 78.084; oxygen — 20.9467; argon — 0.934; carbon dioxide — 0.0314; neon — 0.001818; helium — 0.000524; methane — 0.0002; krypton — 0.000114; hydrogen — 0.00005; nitrogen protoxide — 0.00005; xenon — 0.0000087; sulphur dioxide — from 0 to 0.00001; ozon — in summer from 0 to 0.000007 and in winter — from 0 to 0.000002; nitrogen dioxide from 0 to 0.000002. Traces of ammonia, carbon monoxide and iodine are also detected in the atmosphere.

Atmospheric Pollution and Its Sources

It is necessary to differentiate between natural (biological) and artificial pollution factors whose spheres of influence are rather different.

A scheme of atmospheric pollution sources is presented in Fig. 18. Natural pollution sources include dust (soil-erosion, vegetable, volcanic, marine, cosmic); products of plants, animals and microorganisms, gases (volcanic, from forest and steppe fire), etc. In most cases, they do not carry any negative 'charges', because they do not contradict with biological balance and are within limits of one or another law of matter existence and are controlled by a general cycle of substances in nature.

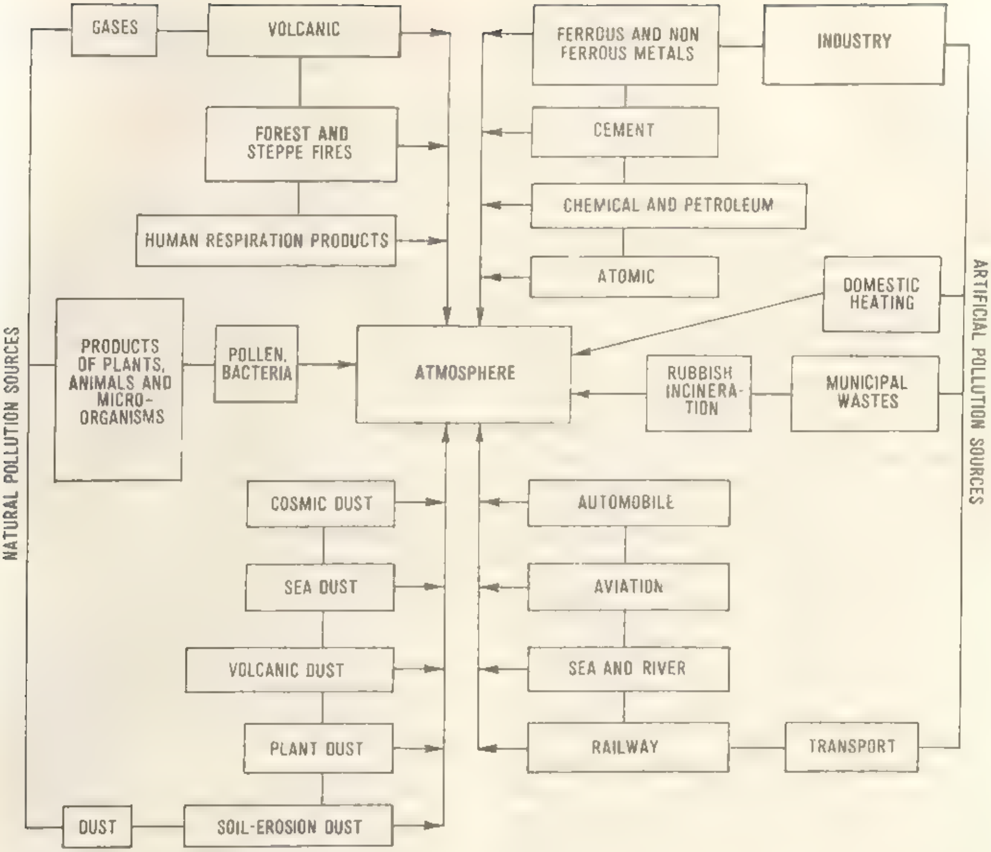


Fig. 18. Main sources of atmospheric pollution.

The other group of the sources which unite artificial factors characterizes the level of technological progress impact. Under certain conditions, beyond the maximum established standards, they can cause local disturbances in biologically established relations and dependences, air, and water poisoning above maximum permissible limits, affect life-support systems of people, animal and plant kingdoms and destabilize the ecologic balance in some region. These factors include development of transport (railway, sea, river, air and automobile), of industry, particularly heavy industry (ferrous and nonferrous metallurgy, mining, chemical, petroleum, atomic, etc.) or public utilities.

The share of artificial sources in the pollution structure varies and cannot be accurately estimated at present. However, their impact on the atmosphere is united, interrelated and complex. Nothing in nature occurs separately; each phenomenon affects others and vice versa. This fact of all around motion and interaction being forgotten is in the majority of instances the reason why some nature students cannot see clearly even the simplest thing [48].

The above applies to atomic power engineering. The annual growth of high-output atomic power stations amounts to about 20 per cent. In 1965, in the world there were thirty-five such stations in operation and approximately

thirty under construction. In 1970, there were 479 nuclear reactors in the world. It is predicted that by the year 2000, between 25 and 50 per cent of the world's electric energy will be produced by atomic power plants (APP), with the total power of $2.13 \cdot 10^6$ MWt giving thousands of tons of radioactive waste. One should also bear in mind that there are as many as 1000 nuclear-powered commercial and navy vessels in the ocean [49].

Atomic industry (uranium ore processing and nuclear fuel producing plants), atomic power stations, vessel and rocket nuclear propulsion systems, and research institutions constitute the principal sources of artificial radioactive contamination. The quantily of radioactive waste is not enormous — it amounts to several thousand million Curie; the major portion is average-life nuclides. Nonetheless, according to the estimations, the amount of artificially-produced radiation will grow a hundred times during the forthcoming decades. That is why the problem of environmental protection from radioactive contamination and that of radioactive waste burial in particular are regarded as most urgent. By the year 2000, the activity of radioactive waste will be equal to that of all radioactive elements available on the Earth [50].

There are several physicochemical radioactive waste disposal methods. Waste discharge into fresh and sea water bodies was for a long time considered to be most safe since radioactive substance concentration becomes much lower due to effective dilution. Later even the most safe containers proved to preserve watertightness only for several decades at the depth of 4 km whereas the radioactive decay period of cesium is 3 million years, that of zirconium — 1 million years, etc. Then, another method of disposal was introduced — the method of underground waste burial. With this method, a considerable part of radioactive products is kept within upper ground layers and interacts with soil. However, via partial migration, the waste gets into the ground water and therefrom into the rivers. The ground water leakage of radioactive waste into the Clinch River near the Oak Ridge atomic plant (United States) was reported to have grown fifty times in three years.

As to gaseous radioactive waste discharge into the air by ventilation ducts, the height of the latter is enough to provide for the dissipation of radioactive contamination in large volumes of atmospheric air and thus prevent fall-out. Certain part of the waste, however, falls down affecting animals, plants, and human health.

Considerable atmospheric pollution is also connected with the use of other energy resources. In the period from 1850 to 1958, 90,000 million tons of coal burnt on the Earth resulted in the fall-out of about 18,000 million tons of slag including 3,000 million tons of silicon, 1.5 million tons of arsenic, over 1 million tons of nickel, 900,000 tons of cobalt, 600,000 tons each of zinc and antimony, etc.

At present, this process has become considerably more active; half the total fuel consumption by mankind was burnt in the last thirty years. According to United Nations data, coal consumption exceeds 2000 million tons per year. This is accompanied by emission of 15,000 million tons of carbon dioxide. Great quantities of carbon dioxide fill the atmosphere as a result of burning oil, natural gas, shale, peat and firewood in ovens and engines, as well as during forest fires and volcanic eruptions. The carbon dioxide content in the atmosphere is at present $2.3 \cdot 10^{12}$ tons and will grow to 4000 thousand million tons by the year 2000. In the United States alone, daily industrial discharges are over 472 thousand tons of soot, dust and ash. In the Federal Republic

of Germany, the daily dust discharge amounts to about 55 thousand tons.

Owing to antipollution laws adopted, the level of atmospheric pollution in certain countries has somewhat decreased.

But whatever the positive achievements in atmosphere pollution control, much more remains to be accomplished in the future, since the amount of pollution grows with the accelerating rates of progress in sciences and technology due to the increasing total volume of principal pollutants which are classified as follows.

Carbon dioxide is formed during combustion of various carbon-containing compounds (power production industry, heating).

Carbon monoxide results from incomplete combustion of mineral fuel (coal and petroleum); the main pollution sources are metallurgy, refineries and internal combustion engines.

Sulphur dioxide is contained in the smoke from energy plants and industrial enterprises, exhaust gases and domestic fuel.

Oxides of nitrogen are contained in the smoke from internal combustion engines, jet engines, blast furnaces, chemical industry enterprises, chemical fertilizers and forest fires.

Mercury is contained in mineral fuel combustion products, in the waste of the industry of dyes and lacquers; and in products of wool-pulp and paper industry, mercury release is observed during ore concentration.

Lead is added to gasoline to increase its anti-detonation properties; it is emitted with exhaust. It is also a component of the waste of lead-containing ore processing and chemical industry.

Radiation results from nuclear fuel production, as well as from nuclear weapon manufacture and testing and operation of nuclear fuel vessels.

In addition, it should be born in mind that there are some 140 varieties of toxic substances in dust and gaseous waste. Their physicochemical composition, nature, possible interactions and consequences are either unknown at present or have received insufficient study, particularly as regards the additive effect, i. e. their combined action.

Combustion of mineral fuel and production of heat energy, pollution of the atmosphere with dust and gases, including carbon dioxide accumulation, under existing rates of industrialization may lead to the so-called greenhouse effect. In other words, it may cause the warming up of the planet's climate by 20 per cent.

On the basis of this hypothesis, one school of thought concludes that if such a temperature rise occurs, in some decades the polar ice would melt and New York, London, Rotterdam, Rome and other coastal cities would be flooded. Some fauna species will vanish even earlier.

Another school of thought maintains that no heat disbalance would occur, since the temperature rise would intensify water evaporation, thus increasing the cloud cover protecting the Earth from solar radiation.

Still another school of thought considers that the increase of gas and dust formation will result, on the contrary, in a cooling down of the climate rather than a greenhouse effect. This would result from the increase in solar radiation reflected by the dust layer.

The majority of scientists participating in 1979 World Conference on Climate in Geneva supported the observed general tendency of the climate warming up due to carbon dioxide emission from mineral fuel combustion into the atmosphere. The specialists from the Federal Republic of Germany maintain that the doubling of carbon dioxide concentration in the atmosphere will bring about a 2 °C temperature rise. The greatest increase will be observed on the Poles.

At present, however, it is difficult to give preference to any of the above theories since for future prognostication on the basis of available data on the growth, one should also take into account many parameters unknown as yet. One thing is clear — with all alternatives of industrial development, one should strive to reduce the amount of pollution, at least to the level of existing standards. Obstacles to this include continuous attempts by industrial firms, corporations and local administrations to violate established air quality standards since respecting them involves additional financial expenses, affects competition, delays the introduction of new industrial products and decreases production capacities and/or the amount of profit on capital.

The concentration limits of carbon monoxide should be decreased from 15 to 3.4 g. Some American congressmen regard the harmfulness of nitrogen dioxide emission as unproved and draw public attention to the facts of unjustified high prices of cars and industry stagnation connected with further emission control.

These and other obstacles to atmosphere pollution control decrease the effectiveness of adopted laws. Walker and Storper stated that after the introduction of the Clean Air Act, it became evident that, given existing conditions in the United States, the problem of ambient air quality could not be solved effectively by legislative means; the quality of air had not improved, nor had the targets of the Act been achieved. State regulations for environmental protection are not efficient tools of control. In spite of certain achievements in air pollution control, state control in its present form does not possess necessary capacities for complete success. However, growing awareness of the danger of environmental pollution has resulted in a dramatic change in public attitude to the problem — and acceptance of the need for intense government control in this field.

Outcome of Atmospheric Pollution

The greatest concentrations of poisonous substances in the atmosphere are observed in large administrative and industrial centres. According to Detries, the monthly fall of industrial soot per 1 square kilometre amounts to 34 tons in Tokyo and 17 tons in New York. Air pollution from car exhaust is a serious cause of trouble. In Los Angeles about 4 million cars emit daily into the atmosphere some 10,000 tons of carbon monoxide, 530 tons of nitrogen oxide and 2,000 tons of hydrocarbons. In Mexico City, the emissions of over 800,000 cars fill the air with 4,000 tons of carbon monoxide. Annual atmospheric pollution with lead is 20 and 15 tons in Geneva and Philadelphia (United States), respectively [12]. According to present estimations, the thickest world smog may be expected in Sydney (Australia). The city air receives daily 660 tons of hydrocarbons (346 tons from cars and 104 tons from oil refining, storage and handling plants) which seriously endanger the inhabitants [51].

As regards city atmosphere pollution with suspended particles (concentrations of sulphur dioxide, carbon monoxide and carbon dioxide). India is one of the most affected countries in the world, with the pollution level being as high as 700 micrograms per cubic metre. Annual dust and solid particles fall in Delhi is several times greater than that permitted by the standards of the United States and West European countries. The highest carbon monoxide in the air is observed in Calcutta [52].

According to the Mexican Public Health Administration, average monthly

Table 20

Crop Yields as Related to the Distance from the Source of Atmospheric Pollution (%)

Crop	Distance		Crop	Distance	
	2-3 km	5 km		2-3 km	5 km
Grass	14.4-24.2	7.2-12.1	Barley	24.4	12.2
Clover	33.1	16.6	Wheat	18.7	9.4
Lucerne	37.8	18.9	Rye	15.2	7.6
Silage crops	22.2	11.1	Flax	62.6	31.3
Corn	25.0	12.5	Potato	35-47	18-24
Oats	31.1	15.5	Beet	25-62	13-31

sulphur dioxide concentrations in Mexico City increased considerably from 1976 to 1978 as a result of industry and transportation development, the high sulphur content in the fuel, and the absence of antipollution legislations limiting sulphur dioxide concentration in the air. High concentration of suspended particles (over 250 milligrams per cubic metre) is observed in the northern and southern parts of the district. Another serious air pollution factor is smoke, the impact of which is growing in the dry season [53].

The study of atmospheric pollution consequences is far from being complete; however, the results to date show that uncontrolled atmosphere pollution leads to acute and chronic intoxications, aggravates various illnesses, gives rise to the new ones, sometimes lethal. In particular, allergies, malignant tumours, leucoses, anemias, psychoneurological disorders, blindness, amnesia, sterility, etc. are progressing. An increase in the occurrence of cardiovascular diseases, bronchitis, emphysema and lung cancer has also been observed [54].

Photochemical smog, a mixture of fog and smoke, consisting of many toxic substances, has tragic consequences. Heavy atmospheric pollution with smog observed in London (United Kingdom), Los Angeles (United States), Donora (United States) and the Meuse River valley (Belgium) caused the death of many thousands of people. According to the London Royal Therapy College, the four-day dense cold fog blanket in Greater London in 1952 resulted in 3500 to 4000 deaths from bronchitis, other pulmonary diseases, coronary vessel troubles, myocardial dystrophy and other illnesses. Air pollution was the cause of death of hundreds of people in New York in 1958, 1963 and 1966. In 1975, this figure was reduced to fourteen. Atmospheric pollution has detrimental effect on animals, as well. In the United States (California), the United Kingdom and Sweden, molybdenum compounds were found to produce a negative effect on ruminants. Having penetrated into soil, molybdenum causes a loss in weight, metabolic disorders and poor growth of bones and tendons [54]. In some industrial regions of Federal Republic of Germany and Sweden bee-keepers noticed an increased mortality of bees caused by the intake of fluorine compounds from industrial exhausts falling on nectariferous plants.

Heavy atmospheric pollution also affects the life of plants. In Sweden, for instance, sulphur dioxides waste from the cellulose industry and thermal power stations using petroleum fuel disturbs the assimilation of pine trees. The exhausts of sulphite boiling mills are the most harmful. Sulphur dioxide concentration in the air at a 3 kilometres distance from the mill amounts to

2000 milligrams per cubic metre which is high enough to damage the assimilating capacity of trees. Trees growing at a 12 kilometres distance from the mill showed in the period of 1945-1970 a 17 per cent growth decrease, mainly due to soil oxidation. Fifty to one hundred year old trees at a 0.5 to 1 kilometre distance from the mill for the same period showed a 24 per cent growth decrease. With older trees, the decrease reached 35 per cent.

Entering soil and water by precipitation, atmospheric pollutants directly affect the life of plants. Pollution causes approximately a threefold decrease in biochemical activity of forest litter degradation and a 1.5-fold one in that of soil in drying forest plantations as compared with healthy ones [55]. The impact of industrial exhausts decreases the bonitation of forest by 1 to 2 classes and in some by 2 to 3 classes [56].

The impact of atmospheric pollution on crop yields is shown in Table 20 [57]. The yield of crops increases with distance from the atmospheric pollution source. The Czechoslovak researchers Kozel and Malyi report the yield decrease caused by industrial pollution to be 43, 36, 35 and 26 to 27 per cent for silo corn, feed beans, sugar beet and grain crop, respectively [58]. According to Polish specialists, a 2 to 3 fold decrease in potato and sugar beet yields is observed. In the United Kingdom, losses in vegetable growth amount to between 50 and 90 per cent.

In general, the negative consequences of atmospheric pollution affecting human beings, animals and plants lead to growing expenses to compensate the ecological losses.

Damage Caused by Atmospheric Pollution

The National Oceanic and Atmospheric Administration (NOAA) Meteorological Service (United States) reports the carbon dioxide concentration in the Earth's atmosphere is continually increasing. This increase was registered by all NOAA stations, save at the South Pole.

At present, the atmosphere of the Earth receives 5,000 million tons of carbon dioxide annually. By 2000, this figure will have increase to 12,000 million tons [47].

A rise in atmospheric pollution leads to direct losses of material and monetary resources. But there are no generalized statistical data on the damage caused to world economy by this negative factor.

However, the information available now is quite sufficient to estimate the range of present and future expenses necessary to compensate for the damage unless timely measures are taken to reduce and eliminate it.

In the United States, between 1951 and 1966, losses caused by atmospheric pollution increases 10 times and reached $ 11,000 million, leaving aside the damage caused to the health of population [59]. In 1968, this figure already reached $ 16,800 million including damage to public health (estimated $ 6,100 million), losses caused by the destruction of buildings ($ 5,2000 million) and these caused by the damage of materials and plants ($ 4,900 million) [60].

New York alone suffered losses amounting to $ 16 per head of population caused by destruction of buildings, equipment and materials. Similar losses in Chicago, Milwaukee and Indianapolis were $ 20, $ 17 and $ 14 per capita. To restore metal structures, Cleveland spends $ 6 million annually: similar expenses in Pittsburgh and Chicago amount to $ 10 and $ 50 million, respectively [57].

In other countries, the amount of economic loss caused by atmospheric pollution is estimated as follows. In 1970 in France and the United King-

dom, it was \$ 3,000 and \$ 840 million, respectively [61]. In Canada, the amount of expenses by 1980 had reached \$ 2,500 million. In Italy, pollution-caused damages in 1968 cost \$ 560 million. The atmospheric pollution impact on cultural treasures in Italy was estimated as 36,000 and 42,000 million liras in 1968 and 1970, respectively, whereas by 1985 it might grow to 134,000 to 158,000 million liras [62]. In Japan, damage caused by environmental pollution grew from 35,000 million yen in 1955 to 6 trillion yen in 1970 [60].

In 1973 in the USSR, according to preliminary information, losses caused by corrosion of building structures amounted to 13 million roubles at plastic and synthetic resin plants alone, whereas in the chemical industry as a whole losses reached 350 million roubles [63].

In 1975, the damage caused to the USSR economy by the loss of raw materials and products through industrial exhaust exceeded 500 million roubles; according to economic calculations, damage caused to human health by atmospheric pollution estimated per head of population was as follows: acute respiratory diseases — 38 roubles; influenza 307 roubles; conjunctivities — 69 roubles; otholaryngological diseases — 84 roubles: bronchitis — 115 roubles; bronchial asthma — 138 roubles; hypertension — 230 roubles; stenocardia — 345 roubles; myocardial infarction — 691 roubles; angina — 84 roubles; tuberculosis — 1382 roubles; pneumonia — 161 roubles; and emphysema — 320 roubles [57].

Thus, in all branches of the economy, especially in the industrialized countries, due account should be taken of material damage caused by atmospheric pollution both in productive and nonproductive spheres of human activity since it results in substantial inroads into GNP.

Standardization of Atmospheric Air Quality and Air Pollution Control Measures

Quality standards for atmospheric air as those for other components of the environment are basic requirements limiting exhaust of various pollutants into the air basin. At present there are two systems of quality standards for the atmosphere — those based on maximum permissible concentrations (MPC) and those using as a basis maximum permissible emission of harmful substances in the air.

The maximum permissible concentrations of harmful substances in the atmospheric air of settlements in the USSR were approved in 1971. Some of those are shown in Table 21.

If there are several substances with additive effect in the atmospheric air, the sum of concentrations should not exceed unity:

$$\frac{C_1}{MPC_1}+\frac{C_2}{MPC_2}+\ldots\frac{C_n}{MPC_n}\leqslant 1,$$

where C_1, $C_2 \ldots C_n$ are efficient concentrations of harmful substances in the atmospheric air; MPC_1, $MPC_2 \ldots MPC_n$ are maximum permissible concentrations of harmful substances in the atmospheric air.

The additive effect is typical of the following combinations of harmful substances: acetone and phenol; acetaldehyde and vinyl acetate: valerianic, capronic and butyric acids; ozone, nitrogen dioxide and formaldehyde; gaseous sulphur dioxide and phenol; gaseous sulphur dioxide and nitrogen dioxide; gaseous sulphur dioxide and hydrogen fluoride; gaseous sulphur dioxide and sulphuric acid aerosol; hydrogen sulphide and dinyl; gaseous sulphur dioxide and hydrogen sulphide; isopropyl benzene and isopropyl benzene hydroperoxide; furfurol, methanol and ethanol;

Table 21

Maximum Permissible Concentrations of Certain Harmful Substances in the Atmospheric Air of Settlements in the USSR

Substance	Maximum permissible concentration, 14 mg/m³	
	maximum instant	average daily
Mercury metal	—	0.0003
Nitrogen dioxide	0.085	0.085
Nitric acid		
as HNO_3	0.4	0.4
as hydrogen ion	0.006	0.006
Acrolein	0.03	0.03
Carbon black (soot)	0.15	0.05
Amyl acetic ester	0.1	0.1
Lead and compounds (excluding lead tetraethyl as Pb)	—	0.0007
Amylene	1.5	1.5
Ammonia	0.2	0.2
Aniline	0.05	0.03
Acetaldehyde	0.01	0.01
Sulphocarbon	0.03	0.005
Acetone	0.35	0.35
Sulphuric acid as H_2SO_4	0.3	0.1
Acetophenone	0.003	0.003
Sulphurous acid anhydride	0.5	0.05
Benzene	1.5	0.08
Gasoline (petroleum derived, low sulphur), as C	5	1.5
Shale gasoline (as C)	0.05	0.05
Butane	200	—
Butylacetate	0.1	0.1
Butylene	3	3
Hydrogene sulphide	0.008	0.008
Butanol	0.1	—
Butyphose	0.01	0.01
Valerianic acid	0.03	0.01
Vanadous pentoxide	—	0.002
Vinyl acetate	0.15	0.15
Hexamethylene diamine	0.001	0.001
Hexachlorocyclohexane	0.03	0.03
Divinyl	3	1
Diketene	0.007	—
Dimethyl aniline	0.0055	0.0055
Dimethyl sulphide	0.08	—
Dimethyl amine	0.005	0.005
Dimethyl disulphide	0.7	—
Dimethyl formamide	0.03	0.03
Dinyl	0.01	0.01
Dichlorethane	3	1
2,3-Dichloro-1,4-naphthoquinone	0.05	0.05
Diethyl amine	0.05	0.05
Isopropyl benzene	0.014	0.014
Isooctanol	0.15	—
Isopropyl benzene hydroperoxide	0.007	0.007
Isopropanol	0.6	0.6
Caprolactam (vapours, aerosol)	0.06	0.06
Capronic acid	0.01	0.005
Carbophos	0.015	—
Acetic acid	0.2	0.06
Ethanol	5	5
Ethyl acetate	0.1	0.1
Ethyl benzene	0.02	0.02
Ethylene	3	3
Ethylene oxide	0.3	0.03
Ethylenyline	0.001	0.001
Freon-11	100	10
Freon-12	100	10
Freon-21	100	10
Freon-22	100	10
Trichlorethylene	4	1
Higher aliphatic amines (C_{16}—C_{20})	0.003	0.003
Milbex	0.2	0.1
Toluene diisocyanate	0.05	0.02
Tricresol	0.005	0.005
Benzopyrene	—	0.1 μg/100 m³
Isooctanol	0.15	0.15
Thiophene	0.6	—
Penicillin	0.05	0.0025
Oxytetracycline	0.01	—
Toluene	0.6	0.6
Tetracycline	0.01	0.006
Triethylamine	0.14	0.14
Oxytetracycline chlorhydrate	0.01	—
Dust (nontoxic)	0.5	0.15
Tepreme	0.002	—
Propanol	0.3	0.3
Monothioethylene glycol	0.07	0.07
Propylene	3	3
Ethylene sulphide	0.5	—
Tetrahydrofuran	0.2	0.2
B-Diethyl aminoethylmercaptan	0.6	0.6
Styrene	0.003	0.003
Hydrocyanic acid	—	0.01
Hydrochloric acid, as HCl	0.2	0.2
Carbon oxide	3	1
Carbon tetrachloride	4	4
Acetic anhydride	0.1	0.03
Phenol	0.01	0.01

Table 21 *(continued)*

Substance	Maximum permissible concentration, 14 mg/m^3	
	maximum instant	average daily
Formaldehyde	0.035	0.012
Phosphoric anhydride	0.15	0.05
Phthalic anhydride (vapour, aerosol)	0.1	0.1
Fluorine compounds (as F):		
gaseous compounds (HF, SiF_4)	0.02	0.005
soluble inorganic fluorides (NaF, Na_2SiF_6)	0.03	0.01
poor soluble inorganic fluorides (AlF_3, Na_3AlF_6, CaF_2)	0.2	0.03
combined gaseous fluorine and fluorine salts	0.03	0.01
Furfurol	0.05	0.05
Chlorine	0.1	0.03
Chloroprene	0.1	0.1
Chloraniline (meta)	—	0.1
Chlorophos	0.04	0 02
Chlortetracycline (feed)	0.05	0.05
Chlorine (6-valence) as CrO_3	0.0015	0.0015
Cyclohexane	1.4	1.4
Cyclohexanol	0.06	0.06
Cyclohexanone	0.04	—
Cyclohexanonoxime	0.1	—
Epichlorhydrin	0.2	0.2

cyclohexane and benzene, strong mineral acids (sulphuric, hydrochloric and nitric) determined as hydrogen ions; ethylene, butylene and amylene; 2,3-dichloronaphtoquinone and 1,4-naphthoquinone; acetic acid and anhydride; acetone and acetophenone; benzene and acetophenone; phenol and acetophenon; sulphuric and sulphurous anhydride, ammonia, nitrogen oxides, acetone, acrolein, phthalic anhydride, acetone, furfurol, formaldehyde and phenol; aerosols of vanadium pentoxide and manganese oxides; vanadium pentoxides aerosols and sulphurous anhydride: aerosols of vanadium pentoxide and chronium trioxide; carbon oxide, nitrogen dioxide, formaldehyde, hexane, sulphurous anhydride, carbon oxide, phenol and converter dust; substances possessing potentiation effect; hydrogen fluoride and fluorine salts with the coefficient of 0.8.

The United States standards of ambient air quality are rather flexible: there are two standards of MPC for major pollutants (Table 22) [47]. Primary standards are first of all public-health oriented, whereas the secondary standards are directed more to protecting material articles and natural resources.

Standards based on maximum permissible industrial exhaust levels are used in the United States to control the admission of the most toxic pollutants from existing sources and newly-introduced industrial plants. Utmost attention is paid to special standardization programmes for new pollution sources. The exhaust standards for the latter are shown in Table 23 [47].

In the USSR, guidelines for establishing permissible levels of industrial exhaust emissions were approved in 1978. Standards controlling industrial exhausts and, primarily, those of existing plants, enterprises and organizations located in the areas of high environmental pollution are to be developed and submitted for approval based on established MPC. Later, these standards are due for further revision, the target being complete elimination of emissions polluting the environment.

In the Federal Republic of Germany, the government establishes national standards of air quality, under the direct control of local executive organs. There is a state inspection system concerned with granting permission for the construction of new industrial enterprises and with the right to temporarily close down plants that do not adhere to established standards.

Table 22

National MPC Standards for Ambient Air Quality in the United States

Type of pollutant	Primary standard	Secondary standard
Suspended particles (solid particles and droplets in the air, including dust, smoke, fog, vapour and splashing of various sources)	75 μg/m³ — annual geometrical average; 260 μg/m³ — maximum daily average	60 μg/m³ — annual geometrical average; 150 μg/m³ — maximum daily average
Sulphur dioxide (heavy, irritating, colorless gas; coal. petroleum, etc. combustion product)	80 μg/m³ (0.03 ppm) — annual arithmetical average; 365 μg/m³ (0.14 ppm) — maximum daily average	1300 μg/m³ — (0.5 ppm) maximum average for 3-hour period
Carbon monoxide	10 mg/m³ (9 ppm) — maximum average for 8 hour period; 40 mg/m³ (35 ppm) maximum average for 1 hour period	The same as primary
Photochemical pollution (ozone type, irritating, colorless, toxic gases, one of the photochemical smog components)	160 μg/m³ (0.08 ppm) — maximum average for hour period;	The same as primary
Nitrogen dioxide (brown toxic gas, fuel combustion product)	100 μg/m³ (0.05 ppm) — annual arithmetical average	The same as primary

Table 23

Emission Standards According to the United States Programme of New Pollution Sources Control

Type of industry	Units of production	Pollutant	Concentration (g per unit of production)
Power stations, using:	1 mill. B.T.U. *	nitrogen oxides	318
coal	»	sulphur oxides	545
petroleum products	»	nitrogen oxides	136
»	»	sulphur oxides	363
natural gas	»	nitrogen oxides	91
any fuel **	»	solid particles	91
Nitric acid plants	1 ton	nitrogen oxides	1360
»	»	sulphur oxides	1820
Sulphuric acid plants ***	»	acid aerosols	680
Cement plants ****	per ton of feed	solid particles	136

* B.T.U. is a British thermal unit equalling 0.252 kcal;

** Permissible air transparent loss is 20 %;

*** With no visible emission;

**** Permissible air transparency loss is 10 %

In Italy, the 1966 law controlling air pollution provides for the intoduction of standards only for specially selected areas, the limits of which are established by local administration. In other parts of the country, antipollution requirements at plants are established by regional committees.

The 1954 atmospheric pollution law in Belgium lays down that antipollu-

tion recommendations and standards fall within the responsibility of the Ministry of Public Health. In 1971, the government issued several pieces of legislation concerning heating installations and creation of special air protection zones. Atmosphere pollution inspection is used to control adherence to the laws.

In France, according to a 1961 law and the classification for power installations issued in 1964, all industrial enterprises are divided into three groups relative to the environmental impact. Those in group I are prohibited in the vicinity of inhabited areas; those of group II may be located in the vicinity provided the standards are observed; and new group III enterprises may be constructed only if they comply with the existing plan of land use for the given area.

In Norway, the Ministry of Environmental Protection and the Emission Control Council are engaged in introducing national standards, controlling primarily fuel sulphur content. The government stimulates the introduction of up-to-date antipollution technology by industrial companies regardless of the expenses involved, applying the principle that 'those who cause pollution pay'.

There is a centralized atmospheric pollution control system in Sweden. The construction of new enterprises is allowed only after preliminary approval of the Environmental Protection Committee.

A license-based system for construction of environment-polluting enterprises is accepted in the Netherlands. In addition, the transportation and industrial pollution sources are taxed on the basis of fuel consumption, the amount of tax corresponding to the level and components of pollution caused by fuel burning. Taxation fees are invested into the pollution control system and used for the compensation of damages caused by pollution via the 'air pollution fund'.

In the United Kingdom, air pollution control is centralized. A larger part (60 per cent) of the most harmful industrial emissions is controlled by the Royal Inspection of Clean Air. Similar inspection controls industrial pollution in Scotland. Non-industrial pollution sources are controlled by local administration [64].

It should be noted that the ambient air quality standards applied in some countries need further development and improvement. Hygienic, biological, technical and economic criteria should be used as guidelines in developing standards for maximum permissible emission levels of pollutants. The hygienic factor is human health. The basis of the biological standard may be constituted by biologically permissible emission levels. While developing these standards, maintaining the biological balance of flora and fauna should be a criterion.

Standards for technically permissible emissions should take into account both the effectiveness of antipollution technologies and also the complex utilization of raw materials. Ecological damage is recognized by the experts as constituting a basis on which to establish economically permissible emission standards, along with the positive effects of atmospheric pollution and those achieved by the re-use of raw material and fuel recovered by air pollution control systems.

International Activities in the Field of Atmospheric Pollution Control

The most significant event in the air pollution control field was the European Conference on Co-operation in the Field of Environmental Protection held in Geneva in November 1979 under the

auspices of ECE. The conference agenda included problems being the most urgent for Europe, i. e. those of pollutant proliferation between the states and new ways of atmospheric pollution control at great distances. The convention and resolution on inter-state air pollution and the declaration on low-waste and waste-free technology and waste recovery were adopted. The latter summarized recommendations on pollution-free technology. The convention, including a list of actions to be undertaken to reduce the air pollutant transfer across the state borders, was signed by the representatives of thirty-five countries.

Broad co-operation in the field of global air pollution control is sponsored by WHO and WMO. Their programmes constitute the major component of Global System of Environmental Control acting under the auspices of UNEP. Complementing each other, the programmes cover various aspects of the problems,.providing for the monitoring and processing of data on atmospheric conditions, in both rural and industrial areas and background pollution levels.

ECE is trying to unify standards for environmental pollution with lead compounds. The search is under way for chlorine-hydrocarbon and fluorine-hydrocarbon substituents. In this connection, monitoring and data exchange between countries are of great importance; unified norms and standards as well as standard equipment and technology are needed in order to implement anti-pollution programmes [65].

Generally, international co-operation in the field of atmospheric pollution control at government level is progressing rather slowly; despite the efforts of individual countries, it is still at the stage of development. The greatest practical achievement in this field is the Moscow Treaty of 1963 banning nuclear weapon tests in the atmosphere, in the outer space and under water.

Additional Information

Atmospheric pollution not only causes chronic diseases but also increases the number of acute respiratory cases, in children particularly. Inhabitants of areas with polluted air suffer a higher incidence of various respiratory infections.

Other factors, including poverty and overcrowded dwellings, also contribute to development of these diseases, but urban atmospheric pollution produces an additional and independent impact on the frequency of cases. For instance, in some regions of the United Kingdom where the air is heavily polluted, infectious diseases of the lower respiratory tracts in children under two are three times as frequent as in those living in the least polluted regions of the country. Research conducted in Nigeria, Colombia and India also shows that polluted air resulting from house stoves favours the spread of respiratory infections.

Respiratory diseases are often a cause of missing school lessons, reduction in the number of working days, bad condition, and even death. Children who grow up in regions with polluted air sometimes pay the penalty several decades later.

Data are growing in number which offer evidence of the effect of atmospheric pollution on the death rate from coronary disease. In a period of extreme pollution, there are numerous cases of cardiac death caused in part by difficulties in breathing, which increase the load for the heart. Another partial explanation is the effect of carbon monoxide on the heart; this gas is the main air pollutant where automobiles are widely used. The carbon monoxide contained in tobacco smoke and automobile exhaust reduces the oxygen supply to tissues. Even small concentrations of carbon monoxide make heart

functioning difficult. Though in most cases lung cancer results from smoking, atmospheric pollution, evidently, also contributes to this lung cancer epidemic typical of our time.

Industrial waste often contains known carcinogenic substances. A relation has been established statistically between the content of particulates in the air and the frequency of carcinoma of the stomach and prostate. Hypotheses are advanced that nitrogen oxides available in the air, combining with other chemical pollutants, form nitrosamines — substances belonging to the category of the most active of the known carcinogens. Availability of nitrosoamines in the air may account for the higher incidence of lung and other organ cancer in town-dwellers.

Lung cancer is frequent not only in towns but also in regions where there are many copper, lead, zinc smelteries and purification plants. Evidence of the United States National Oncological Institute shows that in areas where such smelteries and plants are concentrated, cancer cases in men are higher by 17 per cent and in women by 15 per cent that for the country as a whole. Arsenic contained in the air near such industrial enterprises is believed to be a probable cause.

Given the sheer number of substances polluting our lungs, perhaps we never would be able to accurately establish the role of radiation present in the air in initiation either of cancer of lungs or its other forms. However, it is clear that plutonium available in the environment due to nuclear explosions and escape of radioactivity at atomic power station threatens not only the present but also future generations.

According to the National Academy of Sciences, elimination of atmospheric pollution with automobile exhaust in the United States would effect a saving of $ 2.5 to 100 thousand million annually. If benefits resulting from the elimination of other pollution sources, much more harmful to health than automobiles, were added to the above, the total profits would reach tens of billions of dollars per year. The benefits for society from the elimination of certain pollutants is obvious. The problem is how to alter the behaviour of individuals and enterprises so that this improvement in social welfare can be achieved [66].

Atmospheric pollution in one country may affect the biological resources of others. Such phenomena acquire ever-growing scale. Acid rain caused by excessive emission of sulphur dioxide, mainly in Europe and North America, has reduced the productivity of many lakes, rivers and forests in countries which are not sources of this pollution.

The atmospheric accumulation of other gases, for example, of carbon tetrachloride and methyl chloroform (used in commercial solvents), nitrogen oxides resulted from decaying nitrogen compounds, freon (used in refrigerators, air conditioners and aerosol sprayers) as well as carbon dioxide, is a potentially more urgent problem in view of its possible impact on climate. In particular, it has been calculated that maintaining freon emission at its present level will result in a 15 per cent reduction in the ozone layer by the middle of the next century, which, in turn, may have a detrimental effect on human health and decrease biosphere productivity.

Considerable changes on the land surface, such as forest felling and the mass-scale construction of dams and irrigation systems combined with expansion of urban settlements also can bring about local and regional changes in climate, including variations in heat and moisture exchange between the earth surface and the atmosphere.

Many aspects of world economy, including power engineering and agri-

culture, should be reoriented to bring an end to or slow down carbon dioxide accumulation in the atmosphere. This involves activation of research at the international and national levels for more accurate estimations of climatic and other changes and their socio-economic consequences [67].

CONSERVATION AND MANAGEMENT OF WATER RESOURCES

Water and Its Role in Life on the Earth

Water is formed as a result of simple chemical combination of one oxygen atom with two hydrogen atoms. In a liquid, solid or gaseous state, water is present in practically all the biosphere layers and is a prerequisite for life on the Earth. It is an obligatory element of all living organisms, the life of which is impossible without water. The human organisms contains 60 to 80 per cent water, bodies of terrestrial vertebrates from 60 to 65 per cent and of fish about 80 per cent. In algae and vegetables, water accounts for 90 to 99 per cent, and in terrestrial plants for 50 to 75 per cent.

Water has unique properties both as a chemical element and as a means of satisfying basic human needs. Water is the cradle of all living beings on the Earth, and at the same time one of the most powerful factors of ecological transformations on the surface, not only of our planet but possibly others.

Regional and Interregional Aspects of Water Management

Even today, about one-third of the planet population suffers from the lack of pure water. The water supply level in developing countries is very low; approximately 90 per cent of the population in these countries have no water pipe-lines and must consume low-quality water. Good fresh water becomes an item of export. Thus, for example, Hong Kong receives water from China and millions of Tokyo's population suffer from water hunger.

Scientific opinion differs as to the estimation of the available water supply for the Earth's population. It has been suggested that available pure water resources will be exhausted during the next century. At the United Nations Conference on water supply problems, held in Argentina, it was noted that the day will soon come when a drop of water will cost more than a drop of oil. Soviet researchers have shown available water resources (taking into account their replenishment) to be quite sufficient to meet increasing human requirements for an unlimited period of time without mass-scale substitution of traditional water supply sources by new ones. However, it is necessary to radically change the attitude to the use of water resources, and give up some obsolete principles of water management planning.

Now, in most countries, available water resources can satisfy only current requirements. The compliance of water resources with the requirements in several countries is shown in Table 24 according to United Nations data [68]. Most countries have the necessary amount of usable water resources. Their water management policy takes into account climatic and regional peculiarities, the level of development and system of economy, the rate of economic growth and availability of usable water resources. In addition, water policy is determined by the prices of fuel and power resources and of water and by the financial potentialities of long-term

Table 24

Compliance of Water Resources with the Requirements of ECE Member Countries

Degree of Compliance	Country
The water resources are sufficient to meet the current and future requirements.	Austria, Belgium, Canada, Czechoslovakia, Federal Republic of Germany, Finland, France, German Democratic Republic, Greece, Iceland, Ireland, Italy, Nethenlands, Norway, Spaid-Sweden, Switzerlan, United Kingdom, United States, USSR, Yugoslavia
The water resources are sufficient to meet the current requirements but not those for year 2000	Bulgaria, Luxemburg, Portugal, Turkey
The water resources are insufficient to meet the current requirements	Cyprus, Hungary, Malta, Poland, Romania, Ukrainian SSR

water resource development programmes. Meanwhile, the correct use of water resources is possible only if theoretical principles of unity of all ecological water sources on the Earth are observed.

A successful solution to water-supply problems can only be achieved by implementing a number of engineering projects to increase quantitatively available water resources, taking into consideration seasonal changes in supply and problems caused by distance. Such projects include, in particular, long-term runoff control by a system of large reservoirs, territorial redistribution of river runoff through intrabasin and interbasin water transfer over great distances from regions abundant in water to those with an acute water shortage. The experience of a number of countries shows that economically these measures are quite profitable and some of them are unique from the technical point of view. For example, a 900 kilometre aqueduct system has been built in California (United States) to carry water. There are over 200 kilometres of aqueduct in the Federal Republic of Germany. In Canada, Italy, Romania and Spain, there are water transfer projects either at the construction stage or at the stage of final design. A water transfer project from Lake Bolmen to some southern cities has been developed in Sweden. A water transportation project from rivers of Alaska and Canada serving seven Canadian provinces, thirty-three American states and three Mexican states was proposed over ten years ago. However, more recently, the advantages of constructing powerful and expensive dams, canals and reservoirs has been disputed. There is a tendency to rethink the principle of savings resulted from large-scale technical designs. According to the Secretariat of the United Nations Water Resource Conference, this tendency may be explained by three circumstances. First, the reliability of large structures is doubtful, even with the most careful attitude to their design; this is confirmed by catastrophic failures of such structures. Second, it is more difficult to obtain the desired predicted effect with large projects because of the deviations from the project determined by a number of unpredictable factors of economical and technical nature. Third, such structures involve undesirable consequences such as population migration, spreading of diseases, etc.

Constructed reservoirs lead to a considerable change in river runoff and, at the same time, play the role of a water user by increasing evaporation losses. By 1975 evaporation losses in all countries totalled 110 cubic kilometres and will increase in the future. This may be avoided by using underground reservoirs, the building of which will be increasingly practised on a large scale.

The advantages of underground water accumulation include the nearly-perfect elimination of evaporation losses, as well as saving considerable areas of usable agricultural lands. Isolation from the surface and low temperature create favourable conditions for preserving the high quality of filtration-treated water, which may then be used without any additional purification.

Underground water is used as drinking water in various countries (e. g., Austria). Bulgaria, Canada, Denmark, Portugal and Spain actively search out new sources of water. In France, the Federal Republic of Germany, the Netherlands, Sweden, the USSR and the United Kingdom underground water replenishment programmes are being carried out. One way of increasing pure water resources is sea water desalination. At present, there are nearly 800 desalinating plants in the world with a total capacity of 1.2 million cubic metres of water per day.

Entire cities in some countries receive desalinated sea water (e. g., Colling in the United States, Shevchenko in the USSR). Oil-rich Kuwait receives almost all of its drinking water from the sea. According to predictions, by 1990 the total capacity of desalinating plants throughout the world will reach 50 million cubic metres per day. Some scientists believe that by the year 2000 about 7 per cent of total water demand in the United States will be met by salt water demineralization. Saudi Arabia is implementing a programme for 2.3 million cubic metres of water to be desalinated per day. Small capacity experimental desalinating plants operate in Belgium, Greece, Italy, the Netherlands, Spain, the USSR and other countries. In the United States, a water quality upgrading plant is under construction on the Colorado River. The plant mixes disalinated water with fresh water from the lower reaches of the river. The Belgian government has made a decision to build a demineralization plant in Ostende with a capacity of 40 thousand cubic metres per day. Three such plants are already in operation. In a number of countries, scientific research is aimed at the development of desalinating plants combined with atomic power stations. Such a desalinating method is considered the most promising [68]. The world's first atomic desalinating plant is under operation in the town of Shevchenko (USSR), where the combined production of electricity and heat results in large-scale sea water desalination. The energy is generated by a fast neutron reactor.

Thus sea water desalination is one of the alternative solutions to the problem of water shortage in some regions. The final decision on water supply alternatives depends on the economic efficiency and technical background of large-scale desalinated water production. Experience shows that present water desalinating technique has no economic advantages as compared with traditional methods of territorial water redistribution.

As a result of the accelerated exhaustion rate of fresh water in regions of intense water consumption, man in the future will be forced to make use of desalinated water more and more frequently and this in turn will encourage technological progress in desalination.

In connection with the expected acute shortage of fresh water, the question of Arctic ice in the future as a water supply source has been raised. According to rough calculations, the influx of fresh water into the ocean from icebergs broken off the Arctic glaciers is equal to the fresh water supply by precipitation over the United States (the average annual standard is 760 mm). Economic calculation showed the expenses for fresh water production from an iceberg transported to the South California coast would be lower by a factor of

Table 25

World Water Use Dynamics, km³ per Year

Water user	1900	1940	1950	1960	1970	1975	1985	2000
Population	20*	40	60	80	120	150	250	440
	5	8	11	14	20	25	38	65
Industry	30	120	190	310	510	650	1100	1900
	2	6	9	15	20	25	45	70
Agriculture	350	660	860	1500	1900	2100	2400	3100
	260	480	630	1150	1500	1800	1900	2600
Reservoirs (surface evaporation)	0	1	4	20	70	110	170	240
	0	1	4	20	70	110	170	240
Total	400	820	1100	1910	2600	3000	3920	5980
	267	500	6500	1200	1610	1900	2153	2975

* The total water use is shown above the line, and the consumptive one — under the line.

three than those for water-pipe construction in towns of the state. Saudi Arabia has signed a contract with a French research company to study the possibility of tugging icebergs from the Antarctic to a Red Sea port. Realization of such a project is a matter of the future, since it requires the solution of many sophisticated technical problems.

Structure of Water Consumption and Tendencies to Change It

In estimating the state of water resources, researchers base their calculations on the water requirements of the population, industry and agriculture as well as water use for irrigation, etc. World water usage data, according to UNESCO, up to the year 2000 are given in Table 25.

Agriculture is the most water-demanding sector. The water-use level in agriculture is determined mainly by irrigation, which will be developed intensively in the future. Total expenditure for irrigation is determined by specific volume values of water used, water intake and water returned; it will depend on climatic conditions, crop composition, irrigation methods and the state of irrigation systems. The lowest specific water use for irrigation is observed in European countries (excluding the USSR); 4 to 6 thousand cubic metres per hectare (return water volume being, as a rule, equal to 25 to 30 per cent of intake). In the United States and Mexico, the specific water intake values are 7.5 to 8.5 thousand cubic metres per hectare, with a return water volume of 40 per cent. Asian countries have a lower return water volume — 20 per cent. The greatest volume of water use is characteristic of the northern regions of Africa — 12 to 15 thousand cubic metres per hectare.

In ECE member countries, the major water users are the chemical industry (35 to 40 per cent), metallurgy (30 per cent), the pulp and paper industry (c. 10 per cent).

The share of irrigated land in total agricultural land (excluding pasture) is, expressed as percentages, as follows

Table 26

Total Pollutant Escape (Suspension), mill. t [3]

Area	1970	1980	1990	2000
North America	6.82	6.82	6.82	6.82
Latin America (middle income)	0.76	1.25	2.68	4.86
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Eastern Europe	1.09	1.27	1.57	1.62
[illegible] ning economy)	[illegible]	[illegible]	[illegible]	[illegible]
Japan	0.95	0.95	0.95	0.95
Asia (low income)	0.35	0.63	1.64	3.00
Middle East	0.05	0.39	2.44	4.63
Africa (arid)	0.12	0.18	0.40	0.65
Africa (tropical)	0.08	0.20	0.60	0.68
[illegible] Africa	0.09	0.13	0.32	0.71
Oceania	0.18	0.18	0.18	0.18

in these countries: Belgium — 11.8; Denmark — 2.2; Federal Republic of Germany — 3.7; France — 4.3; Italy — 29; the Netherlands — 14.7; United Kingdom — 1.6. The decade 1960 to 1970 in some European countries saw an eight-fold increase in water intake and only a five-fold rise in water consumption. In all water-using sectors, [illegible] in industry a tendency to slowing down is observed. In Italy, in the ferrous metallurgy industry, over half of the [illegible] per cent of which undergoes special treatment. Italy uses 50 million cubic metres of sea water per year.

A two-fold urban population rise in [illegible] resources territorial distribution, unfa- [illegible] of annual precipitation. The water use in [illegible] countries is expected to rise by 60 per cent by the year 2000, which will result in an increase of the intake share in the average annual water runoff and precipitation volumes up to 20 and 10 per cent, respectively [69].

Measures on Water Resources Conservation and Protection

Today, when the environmental impact of industry is doubling every twelve to fifteen years, industrial waste discharge to water bodies is a major cause of their pollution; the natural process of water quality recovery is no [illegible] effective. Table 26 shows the pollutant levels for some countries and regions.

Thus, the ever-increasing and sometimes uncontrolled water body use and the continuing pollution of the hydrosphere aggravate the danger of water resource depletion and call for radical change in attitudes towards water consumption. Mankind must become aware that one has approached that limit which may have a negative influence on the ecological foundation of life on the Earth. [illegible] development reflects the present consumption-oriented approach to nature and water resources.

[illegible] many European countries have effected [illegible] arrangements in the field of water resources conserva- [illegible] departments in the country. In the United Kingdom, [illegible] Water Resource Law, control is exercised by ten regional water resource committees in [illegible] for waste discharge. [illegible] to establish

Table 27

General Requirements in the USSR for Composition and Properties of Water in Water Supply Points of Domestic and Municipal Water Use

[illegible]	[illegible] ...plic catering water supply [illegible] ...bodies in populated areas	
Suspended substances	Must not [illegible] [illegible] mg/l	0.75 mg/l
	[illegible] of suspended substances is allowed [illegible] ...ies with over 30 mg/l mineral content at mean low water [illegible] ge	
Floating impurities (substances)	[illegible]	
Smells, tastes	[illegible] ted before or just after chlorination are not permitted Water should not add smell and taste to food fish	
Colour	Water should be colourless in the column of 20 cm	10 cm
Temperature	[illegible] hottest month of the year for the last [illegible]	
Reaction	Should be within 6.5 to 8.5 pH	
Minerals	1000 mg/l of dry residue (max) including 350 mg/l of chlorides and 500 mg/l of sulphides	[illegible] ristic [illegible]
Dissolved oxygen	[illegible]	
Biochemical oxygen demand	[illegible]	[illegible]
Pathogenic bacteria	[illegible] disinfection after special [illegible] by disinfection of bio- [illegible]	
Toxic substances	[illegible]	

a unified water protection [illegible]. In Switzerland, the 1971 Water Protection Law [illegible] the maximum perm[illegible] [illegible] law [illegible]ling the pollution of surface [illegible] water prohibits sewage [illegible] Industrial discharges are to be licenced by [illegible] mental Pollution Control. In Denmark, the Ministry of Environmental Protection establishes standards for underground [illegible] The Water Pollution Law, a nation-wide policy in this area, has been established in Italy since 1976 [64].

Rules and Regulations on Surface Water Protection have been in effect in the USSR since 1974 in the context of the fundamental law of the Soviet Union and law of the republics on public health care and the water management legislation. The rules control re[illegible] properties of water in domestic, municipal and industrial water supply points, [illegible] concentrations of harmful substances. The general requirements for water

quality accepted in the USSR are given in Table 27.

In the United States, under the Supplement to the 1972 Water Pollution Control Law, effluents are regulated by applying national water quality standards and national standards for the content of toxic pollutants in sewage water. The application of standards is controlled by means of a special system of licences for waste discharge. For the effluents of municipal treatment plants, the lowest available standard requires secondary water treatment; the second standard requires the introduction of the best available technology of sewage purification.

Industrial standards are established in accordance with present waste discharge norms for 40 sectors and 550 subsectors of industry. There are five standards: (1) the best available technology, (2) the most economically feasible technology, (3) for new enterprises, (4) for waste before municipal treatment plants, (5) the same for new enterprises. Should the standards not result in the upgrading of water quality, the administration establishes a priority system of water use. For every alternative, water quality standards are determined by several parameters laid down in the reference book **Water Quality Criteria** [70].

During the past decade, as a result of the application of various norms and economic methods of water management control, water quality has somewhat improved in several countries and areas. Nevertheless, the state of world fresh water resources remains a cause of great anxiety.

Water Protection Means

Mechanical, chemical and biological methods are used for waste water treatment. Mechanical treatment involves separating sewage into liquid and solid phases. This type of treatment employs special equipment and structures, such as gratings, sand catchers, equalizing and preaerator tanks, biocoagulators, oil traps, hydrocyclones, flotation plants and different sorts of sedimentation tanks, including vertical-, horizontal-, and radial-flow tanks and those with rotary distribution devices, etc. The gratings catch rough and coarse pollutants. Sand catchers stop mineral admixtures. Equalizing tanks are used to equalize composition and discharge of industrial sewage. The capacity of the equalizing tanks depends on the sewage inflow and pollutant concentration variation. Sumps may be used both for final and preliminary (pre-biological) treatment. To increase the efficiency of settling tanks, preaeration is used, i. e. sewage is preliminarily air-treated for a certain period of time. Preaerators, biocoagulators and clarifiers are mainly employed to decrease pollutant level in settled sewage and to extract heavy metal ions and other contaminations adversely affecting biological treatment. Preaerators are located before primary sumps as separate installations, whereas biocoagulators and clarifiers are built in and form parts of vertical sedimentation tanks. At waste treatment plants preaerators are used together with aeration tanks, whereas biocoagulators and clarifiers are combined both with aerotanks and biofilters. Open-type hydrocyclones are applied to separate large-size sediments and coarse floatable admixtures. Displacement-type hydrocyclones separate only settling aggregates — stable coarse structural admixtures. Various floatation plants remove petroleum products, mineral fibres, wool, asbestos and other insolubles.

Chemical water treatment at water mains and sewage works is carried out by means of various chlorine-containing compounds, including sulphur dioxide, bleaching powder, sodium and

calcium hypochlorite solutions. Strong oxidizing compounds, first of all elementary chlorine, are used at high-performance treatment plants. The application of ozone, the most powerful oxidizing substance, is reasonable when waste treatment is accompanied by deodorization. In 1976, over 1000 ozone plants for drinking water treatment and disinfection were available in the world. They are growing in quantity and productivity. Recently a number of large ozone plants has been put into operation in the USSR: in Moscow (1,200 thousand cubic metres per day), Kiev (400 thousand cubic metres per day), Gorky (350 thousand cubic metres per day), as well as in Canada — Montreal (1,200 thousand cubic metres per day), Belgium — Antwerp (3.3 tons per day) and in other countries. Paris receives water from several plants with ozonation facilities: Choisy-le-Roi (900 thousand cubic metres per day), Orly (300 thousand cubic metres per day), Meru-sur-Oise (100 thousand cubic metres per day). Scores of plants having lesser capacity (up to 50 to 100 cubic metres per day) were built. Growing interest in the use of ozonation for disinfection of treated and advanced treated sewage to substitute traditional chlorination has been evinced in the last years in several major cities, including New York. In the United States, there are several plants using the new process with a capacity of 120 thousand cubic metres per day, including one in Springfield (Massachusetts).

Extension of ozone-based technology of water treatment and disinfection is attributed by experts to the following: to more strict sanitary and quality requirements, resulting from the deteriorating sanitary conditions of surface water bodies; to the presence of new polluting detergents, toxic chemical, industrial and other wastes whose presence is little affected by traditional methods of water treatment; to the increased requirements for treatment levels and disinfection of sewage discharged into water bodies specified by more rigid antipollution laws adopted in many countries; to the tendency of recycling sewage; to difficulties of chlorine application such as increased chlorine doses and a long period of exposure to chlorine; to the necessity of storing considerable amounts of chlorine at treatment plants near populated areas; to the necessity of water dechlorination; to an increased deficiency of liquid chlorine used by chemical industry; to achievements in ozone production technology and methods of ozone application for water treatment and disinfection [71].

Biological sewage treatment is connected with mineralization of organic sewage via aerobic biochemical processes. Artificial biological treatment uses trickling and high-rate biofilters with plastic media, mixing, plugflow, intermediate and settling aerotanks. Biological treatment of sewage with high organic substance concentration is typically performed in two stages. At the first stage, depending on sewage composition and organic substance concentration, either aerobic fermentation in methane-tanks or aerotank oxidation is used. At the second stage, biotreatment of this sewage is carried out separately or together with domestic waste water. For biological treatment under natural conditions, sewage treatment ponds are used.

Looking at the problem of water resource protection as a whole, certain factors which adversely affect the quality of surface and underground water and which will be important in the next twenty to thirty years, cannot, unfortunately, be controlled by any technically reliable and economically feasible methods: mineralization of fresh water bodies and underground water-bearing horizons with high-mineralized effluents; thermal pollution of water bodies;

accidental random pattern pollution with toxic chemicals and fertilizers through sruface water from fields and sewage of industrial enterprises and residential areas. Society's general strategy in the area of water protection provides for the economic policy facilitating socio-economic progress in countries with due regard for social development targets relative to the new pattern of economy; it provides for the subordination of the interests of individual water users to those of the entire nation. Water quality improvement, the prevention of water pollution, contamination and overheating, and the elimination of unfavourable variations in energy conditions are among the strategy targets. This strategy permits only such variations in ecological systems of water bodies which cannot become obstacles to future production of water to meet the needs of most water users, above all, the users of potable water. It provides an opportunity to change the environment in view of alternative water use and the special development characteristics of national economics.

A science and technology based social strategy in the area of water resource protection from depletion and pollution comprises the following basic components: the creation and introduction of water-free production techniques; closed water recycling systems in industry which avoid waste discharge into water bodies and provide complete water reuse; the creation of integrated systems of water supply, sewage and water protection measures for industrial regions and entire river basins; sewage discharge into water bodies only in cases where recovery is either impossible or economically unfeasible (the discharged sewage being treated so that it would affect the quality of water in the receiving source strictly within permissible ecological shift limits); improved control of unregulated discharge into water bodies; and the realization of an integrated system of automatic monitoring of natural and waste water composition. Thus the focus of attention on water protection from depletion is shifted from biological components of water ecological systems to technical means of water conservation.

Among the fundamental problems of water protection, the following are the most pressing: the creation of a general system of water resources management, taking into account world-wide and regional situations and the formation of quantity and quality of fresh water; the introduction of versatile forms and methods of carrying out economic evaluations of water resources; the extension of a system of surface and waste water quality monitoring; the development of radically new, waste-free technologies for chemical, pulp and paper, food, light and other branches of industry; the development of efficient and economically feasible methods of mass-scale water desalination; the use of storage reservoirs for the water supply of high-performance thermal and atomic power stations, with subsequent re-use of heated water; the development of methods for controlling runoff from drainage basins surface, soil water regime, and artificial underground water replenishment; the study of the impact of land reclamation on water resources with due regard for the water-protective function of bogs and land with excessively high moisture content; increased efficiency in irrigation systems; the development of new methods of water resource protection from eutrophication; and the development of efficient agricultural, forestry and land reclamation methods for water resource accumulation and protection.

Among these measures, the role of economic means of water protection was underestimated for some time. Economic methods in combination with other factors have acquired greater sig-

Table 28

Tariffs for Water Taken by Industrial Enterprises from Water Management Systems

Water management system	Tariff, kop. per 1 m^3
Basin	
of the Caspian Sea	0.79-1.39
of the Black and Azov Seas	0.59-2.72
of the Baltic Sea	0.35-1.03
of the Aral Sea	1.08-1.61
of Lake Balkhash	0.98-1.61
of the Kara Sea	0.30-1.18
of Lake Baikal	2.00
of Lake Issyk Kul	2.00

nificance, particularly in terms of creating a stable financial fund for water resources protection and regeneration. In the USSR, for example, tariffs for water taken by industry from water management systems have been in effect since 1982 (Table 28).

International Activities in the Field of Water Pollution Control

The United Nations Conference on Water Resources held in 1977 in Mar del Plata (Argentina) was highly significant in the field of water pollution control. Some 2000 delegates from 160 countries attended. The delegates paid considerable attention to the development of various regional actions concerning the rational use of water resources and water quality control. The Conference declared the period from 1980 to 1990 as the International Decade of Potable Water Supply and Quality Improvement and adopted an action plan including the most important international and regional measures in the given field. Among the Conference resolutions, the following are noteworthy: the overall introduction of water pollution monitoring systems; establishing laboratories where required for systematic physical, chemical, biological and bacteriological water analysis; the control of industrial discharge into water sources; the development and general application of universal criteria, standards and methods for the evaluation of water quality, elaboration of water classification based on usage alternatives; and the preparation and constant renewal of lists of pollutants, coupled with the unification of water quality control terminology.

International co-operation in the sphere of water protection and air quality upgrading involves both inter-governmental activity and the participation of non-governmental organizations (NGOs).

Problems of upgrading water quality are within the scope of ECE activity. In accordance with the programme for 1977-1981, the definition of harmful substance has been developed on the basis of investigation of pollutant effects on human beings and living organisms. Based on this definition, a number of recommendations was issued by specially organized commission. In May 1978, the ECE Council specified the quality of water required for life maintenance of marine and river organisms in a recommendation containing lists of especially hazardous pollutants (black and gray lists) and specifying the conditions governing their discharge. Permission for pollutant discharge into water released by ECE bodies should comprise complete information on necessary discharge precautions and the amount of harmful pollutant in the waste. ECE member countries are obliged to provide industries which have toxic emissions with special waste treatment plants meeting existing ECE standards, thereby assuring minimum environmental pollution. A special system of information exchange between national water quality controlling bodies was established to verify conformity with the recommendations [72].

WHO actively participates in water resource protection. During the last decade, the European regional body of WHO includes in its working programme a broad range of relevant problems, especially those connected with reducing pollution in European rivers. Under WHO supervision, projects of surface water quality upgrading are being developed for eleven countries; the WHO programme also includes projects based on international co-operation in this field. Three special publications discussing biological, chemical and physical methods of pollution monitoring were issued in 1979. At present, a global system of environment monitoring is being organized. Its first stage is connected with combining existing monitoring systems with initial data, thereby providing for the comparison of the information obtained in different countries in order to establish a trend in surface water quality change on the basis of long-range observations. Research is also being carried out into toxicity levels and MPC for new ingredients as well as on monitoring of water quality in transit rivers crossing the territories of several countries.

The Soviet-Iran Treaty of 1926 on Protection of Frontier Region Ground Water Basins is one example of international co-operation in this field. The 1959 Soviet-Finland-Norway Treaty on Lake Inary specifies minimum and maximum lake levels whereas the 1964 Soviet-Polish Treaty involves the exchange of hydrological, hydrogeological and hydrometeorological information on frontier water basins.

Treaties between Albania, Bulgaria, Greece, Hungary, and Yugoslavia also envisage mutual information exchange on water management facilities. Yugoslavia and neighbouring countries participate in inter-state commissions on frontier region ground waters. Similar commissions were organized for some European rivers. The United Nations recommends such commissions for North-Eastern Africa and the Arabian peninsula [94].

These and many other facts testify to the constant broadening of the scope and range of international co-operation in the field of water resource protection. For the population of the planet, however, a source of constant anxiety is the fact that over a quarter of mankind suffers from the lack of fresh water and about 500 million people from diseases resulting from water deficiency or low quality. The situation is especially alarming in rural areas of developing countries where over three quarters of the population is not provided with a sufficient amount of water to meet its basic needs.

Water resource competition may result in a confrontation of interests and in conflicts. By the year 2000, the fresh water demand in North Africa and the Middle East will amount to 103 per cent of the available resources.

The United Nations estimation shows that by 1990 the pure water supply of the Earth's population and construction of water treatment facilities will require $ 9,000 million of capital investment, a little more than 2 per cent of the world's armament expenditure. Therefore, the capital resulting from only 2 per cent reduction of armament expenses being invested in water supply improvement on the Earth will make it possible to eliminate fresh water deficiency and reduce mortality induced by low-quality water in many states of Asia, Africa and Latin America [73].

PROBLEMS OF SEA AND OCEAN POLLUTION

Sources of World Ocean Pollution

The main source of the world ocean pollution is oil and its products. Their influx into the aquatic environment is characterized by data given in Table 29 [74].

According to more detailed data, 54 per cent of the polluting oil enters the sea from land sources (waste-water discharged into rivers) and 35 per cent from sea transport (twice as much oil enters the sea due to fuel tank and tanker washing than shipwrecks) [75]. Natural oil shows in oil fields as well as losses in extraction, transportation and refining of oil are also sources of spillage. The total amount of oil entering the ocean may be estimated within a range of 3.28 to 25 million tons; probably over 14 million tons annually [76].

The volume of natural oil influx into the world's oceans is about 0.5 million tons per year. This oil is mainly concentrated in the continental shelf in the coastal area of Southern California, the Gulf of Mexico, the Persian Gulf, the Caribbean and Arabian Seas, near the northern coast of Alaska and Canada and near Indonesian boundaries [77].

In oil extraction, 'volley' outbursts of liquid fuel due to breakdowns and other accidents are quite frequent, which also leads to ocean and sea pollution. For instance, 15 million litres of oil covered an ocean area of 2072 square kilometres because of a leakage from the Santa Barbara oil well (California) [78].

At present, about 70 per cent of world oil output is shipped by sea, and, as a result, oil leakage is increasing at an ever-growing rate due to supertanker accidents. In 1967, the supertanker **Torrey Canyon** accident led to a 110 thousand ton oil leakage. During twenty days there were six supertanker accidents in the coastal area of the United States and more than 13 million litres of oil were released into the American coastal waters [79]. In March of 1978 the supertanker **Amoco Cadiz** was shipwrecked near the north-western coast of France and 220 thousand tons of crude oil entered the sea. A layer of the oil spill 80 cm thick spread 40 kilometres from the scene of the accident. Some 30 to 40 thousand tons of oil were deposited on the seashore while 40 to 50 thousand tons sank to the sea bed. Nearly 70 thousand tons of oil evaporated from the water surface, and it also caused the formation of water-in-oil emulsion with a ratio 2 : 1 [80].

In 1978, 264 vessels with a total gross tonnage of 1.4 million tons perished in shipwreck in the world's oceans due to explosions, fires, cargo displacement, ship grounding, failures and breakdowns of equipment [81].

The United Kingdom Advisory Committee on Oil Pollution pointed out that, in 1978, there were about 500 oil spills near British shores and, as a result, about 800 million litres of oil and oil products entered the sea, which led to chronic pollution of many parts of the coastal area and the killing of fauna [82].

According to the latest data, more than 6 million tons of oil and oil products annually enter the sea (transportation — 34 per cent; land-based sources — 44 per cent; shelf oil extraction — 2 per cent; and natural oil inflows — 20 per cent). Oil pollution due to tanker accidents and well breakdowns accounts for 6 per cent. The Baltic, North and Mediterranean Seas are the most polluted. Some 105 thousand tons of

Table 29

Oil Pollution of the World's Oceans

Source of pollution	Volume, thousand tons per year	%		
Total oil influx *	4897	100		
World Ocean-based sources	2407	49.16	100	
Tankers				
including ballast and backwash water discharge	1457	29.76	60.53	100.0
accidents	967	19.75	40.17	66.37
other losses	282	5.76	11.72	19.35
off-shore oil extraction	100	2.04	4.16	
Water transport				
including operating waste and losses	600	12.25	24.93	70.59
accidents	250	5.11	10.38	29.41
Land-based sources:	2490	50.84	100.0	
including automobile transport	1440	29.41	57.83	
industry	1050	21.43	42.17	100
oil refining and petrochemical industry	300	6.12	12.05	28.57
other industries	750	15.31	30.12	71.43

* Excluding natural oil show, atmospheric fallout and recreational transport release.

oil, including 3 thousand tons of natural oil infiltration from the sea bottom, enter the North Sea from marine sources. Coastal enterprises discharge 220 thousand tons into the sea, i. e. nearly half of the total release; 80 thousand tons (20 per cent) enter the sea as a result of river runoff, and about 10 thousand tons (2.5 per cent) are due to atmospheric fallout [83].

Between 2 and 2.3 million tons of titanium dioxide production waste, 0.8 million tons of aluminium production waste, nearly 0.5 million tons of chemical industry waste, up to 5 million tons of domestic waste of big cities, 1.5 million tons of mine waste and 0.75 million tons of ash from power stations enter the North Sea as a result of economic activity in the Federal Republic of Germany, the Netherlands, the United Kingdom and other countries [84].

The Mediterranean region has been in a precarious situation for quite a long time; its pollution level is six times as high as that of the world's oceans in general specific assessments, seven times in industrial and agricultural wastes, and thirty times in hydrocarbons. There is a close correlation between the content of collibacteria and morbidity of those having holidays at the seaside. The microbiological analysis of coastal water composition in the Tyrrhenian Sea revealed the presence of polioviruses, echoviruses and enteroviruses. Some water areas are affected by eutrophication, especially the region of Emilia-Romania, 130 km from the mouth of the Po River [85].

Concentration of hydrocarbon pollution in the Mediterranean Sea is 108 kilograms per square kilometre (compare with 17.5 in the North Atlantic and 400 in the North Sea). Some parts of the water area, especially near Barcelona, Tarragona, the Gulf of Genoa, the North Adriatic and the Aegean Sea are polluted to a much greater degree. In sum-

mer 1979, twenty-one swimmers were victims of chloride poisoning near Barcelona. The mercury content in the flesh of tuna caught off Carloforte (Sardinia) was seven times the admissible level. A considerable number of coastal enterprises (85 per cent) in France, Greece, Italy and Spain continually discharge untreated industrial waste into the sea. As a result, 21 thousand tons of zinc, 3.8 thousand tons of tin, 2.4 thousand tons of cadmium, 100 tons of mercury and other toxic agents enter the Mediterranean Sea.

Protection of Seas and Oceans

As a result of the high volume of world's ocean pollution, certain states face the task of taking various preventive measures for reducing the emission of pollutants and controlling utilization of the ocean.

Some 11 thousand oil spillages and 35 thousand vast chemical agent spills are observed annually in the United States. The total amount of oil entering the environment is 64 thousand cubic metres a year. An oil spillage control agency has been working in this country since 1968. EPA has imposed controls on proprietors of large stationary oil storages since 1974. Conformity to oil product leakage control standards is checked only when the leakage product amount is doubled for a year or when oil leakage resulting from a large-scale accident exceeds 1,000 gallons, i. e. 3,780 litres. In 1977, the United States oil industry spent $ 2.5 thousand million for environmental control. By 1985, expenditures of this type will reach between $ 10 and 17 thousand million [86].

Successful work on oil spill recovery is being carried out in the coastal zone of the Gulf of Mexico (Texas) where there is an increased accident risk owing to the quantities of refined oil and heavy traffic. In 1971, the Association for Oil Spill Control was set up in this region which concluded as a result of its activity that 90 per cent of recovered oil can be recycled and re-used.

An ocean pollution research programme has been worked out in the United States for 1979 to 1983 in order to determine critical pollution levels, to study processes of dispersion and concentration of pollutants, to detect pollution sources and to develop pollution control methods and procedures.

Oil spill recovery devices and techniques play an outstanding part in oil product pollution control of the marine environment. The Multipol (France) oil recovery system, which has been in existence for nearly ten years and is used world-wide, is a good example of efficient oil spill treatment. The system incorporates the dynamic Cyclonet recuperator, which can treat 600 cubic metres of oil per hour with 3 mm thick film, and the static Nenufar recuperator, which can operate jointly with the Cyclonet recuperator. Vessels with the tractive force of 160 tons, equipped with both recuperators and floating trapping construction as well as oil product storage tanks (7,000 cubic metre capacity) and separation and decantation equipment are used for towing and purification purposes. Barges with the Cyclonet recuperators and tanks with a capacity of 5,000 to 20,000 cubic metres for oil product treatment and storage, coastal oil carrying vessels with the Cyclonet recuperators and separators, and the Navypol fleet including small vessels equipped with the Cyclonet recuperators, oil storage tanks and floating trapping devices are also used [87].

International Activities in the Field of World Ocean Pollution Control

International activities concerned with world's ocean pollution control take the form of international forums

and agreements, intergovernmental and non-governmental working groups and international research programmes. Prominent international forums have included the FAO conference in Rome (1970) on marine environmental pollution and its impact upon fauna and fishery, the Third United Nations Conference on Maritime Law, and the Stockholm Conference on the Human Environment (1972). Apart from FAO, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the Global Investigation of Pollution in the Marine Environment (GIPMF) and the International Marine Committee (IMC; formerly the Intergovernmental Maritime Consultative Organization — IMCO), which co-ordinates activities aimed at reducing marine environment pollution from ships, are dealing with problem of ocean and sea pollution on a worldwide scale. International research programmes include the programme of environment monitoring adopted at the Stockholm Conference in 1972, GIPMF's universal plan for studying sea pollution, a programme for organizing an integrated system of tracking stations in the world oceans, and the programme of the European Space Agency (ESA) Sea Satellite (SEASAT) studying sea surface oil pollution by means of satellites. The International Convention for the Prevention of Pollution of the Sea by Oil (1954) was the staring point of IMCO pollution control activity. Two more conventions were adopted in 1969. In 1971, IMCO encouraged the adoption of the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, which came into force in 1978. The International Convention for the Prevention of Pollution from Ships was elaborated and adopted in 1973, with support from IMCO. The Conference on the Prevention of Oil Pollution and Oil Tanker Safety Measures (London, 1978) adopted a decision stipulating that Annex 2 to the Convention, dealing with oil pollution control of marine environment from chemical tankers, would come into force in 1984. By this time, recommendations to ship owners relating to the building of new tankers and reconstruction of existing ones should be introduced into maritime practice. But even now authorities of any sea port, on the basis of this code, may demand a certificate of the compliance of ship structure with IMCO standards of any tankers entering a port harbour.

The vulnerable point of the IMCO recommendations is lack of composition control for wastes discharged into the sea during oil tank washing. If it were possible to control this procedure, IMCO would give a precise assessment of every case of sea pollution by a cargo ship, introduce unloading limits, work out procedures and methods of control, and provide land-based tanks for operational discharges.

IMCO renders technical assistance to states, provides them with equipment and materials, and experts in the field of navigation safety and ocean purity. The Maritime Safety Agency was set up in 1978 to provide the following states concerned with different kinds of experts.

In 1978, following the Amoco Cadiz incident, problems dealing with marine environment pollution control were discussed at the Paris session of the European Council for Prevention of Pollution of Coastal Waters. The recommendations adopted called on the Council of Ministers of the European Council to focus their attention on the need for member states to ratify numerous international agreements on marine environment oil pollution control. The importance of developing an effective control system for these agreements and adopting stricter sanctions in case of violation was also emphasized. Most participants supported the idea of setting up an international agency which

would be in charge of planning and co-ordinating the activities of existing bodies as well as those of governments concerned with protecting European coastal waters from pollution. According to the Institute of European Policy on Environment Control (Institut pour une politique européenne de l'environnement), the establishment of such an agency should be based on the following legal, scientific and technological premises:

— European Council Member States should ratify the International Convention on the Prevention of Marine Pollution by Dumping of Wastes and other matter (1972); the Convention for the Prevention of Marine Environment Pollution from Ships (London, 1979); regional conventions relating to zones, which are of immediate concern for only a number of individual members of the Council (the North Sea, the Atlantic Ocean) or states concerned which belong to different regional organizations (the Baltic and Mediterranean Seas) such as the Agreement on co-operation for the Prevention of Pollution of the North Sea (Bonn, 1969) and the Convention for the Protection of Marine Environment of the Baltic Sea (Helsinki, 1974). Requirements, stipulated in these conventions as well as in documents of the Third United Nations Conference on Maritime Law, set out the international legal basis sufficient for joint activity in the field of world ocean pollution control;

— the European Agency for the Protection of the Marine Environment should be authorized with independent legal rights regardless of the will of founding states; all states, signatories of the agreement, being vested with equal competence, should be represented in this body; and these states should set up a political decision-making committee;

— the purpose of this Agency is to co-ordinate pollution control activities, to encourage co-operation among the various international organizations concerned, to disseminate and exchange scientific information, and to provide assistance in working out nation-wide measures on pollution elimination [88].

Among the noteworthy measures of world-wide significance is the Protocol, signed in May, 1980, in Athens, for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (which account for 85 per cent of the total pollution of the Mediterranean Sea); $ 15,000 million are to be allocated to achieve these goals. The Protocol consists of sixteen articles and three annexes: Annex 1, the 'black list', enumerates highly hazardous toxic agents (organic pollutants containing halogens, phosphorus, tin, mercury, cadmium and their compounds; synthetic materials which are not subjected to decomposition; lubricant waste; substance with carcinogenic, teratogenic and mutagenic properties; radioactive isotopes, whose release into the sea or waters is strictly forbidden); Annex 2, the 'grey list', contains the enumeration of less toxic agents (antimony, arsenic, vanadium, zink and their compounds; cyanides and flourides; biologically harmful organo-silicon compounds; hydrocarbons, crude oil, surfactants, etc.) whose release into sea waters is strictly limited; Annex 3, the 'white list', deals with various solid wastes entering the sea with the help of the wind.

Despite the adoption of such a treaty, some experts point out that the international environment management activities on pollution control in the Mediterranean Sea do not appear to have succeeded. One of the reasons for this can be found in the gap between the number of adopted agreements on marine environment control and those which have actually come into force. Thus, since February of 1978, of a series of similar agreements, only three have come into effect. Another cause is the

lack of compulsory procedures in the agreements which have come into force in terms of the determination of responsibility and the assessment of damage caused by pollution. Since such procedures are not determined, agreements may only be reached on a voluntary basis with the agreement of the participants. A third reason stems from the fact that the pollution level of the Mediterranean Sea may be reduced by only 20 per cent even if the terms of the agreements which have come into force are respected. Waste from land-based sources in industrial centres and large cities account for the bulk of pollutions, but it is the agreements concerning pollution from land-based sources that appear to be fruitless, for they seem unpopular among states, notably the developing countries which regard pollution control agreements as a violation of their sovereignty over national natural resources.

Two possible ways of solving this problem are to establish a system of compensatory payments and to promote the conclusion of regional agreements. Toxic agents are entering the sea unevenly owing to the non-uniform location of pollution sources. Bearing this in mind, one can assess the damage caused by every polluting country. Furthermore, nation-wide programmes on control of land-based sources of pollution appear to be, primarily, advantageous for states in charge of their implementation. The conclusion of agreements between neighbouring member states of ten existing subdivisions of the Mediterranean Sea basin, according to the 1976 UNEP plan, will result in more favourable conditions for reducing the general pollution level than would one international agreement which incorporates all the states of this region. The Treaty for the Prevention of Pollution of the Great Lakes between the United States and Canada may serve as a good model for such agreements.

Additional Information

Many rivers empty into the Baltic Sea and its surface layer is therefore strongly desalinated. More saline and heavy water remains near the bottom, and less saline, rich in oxygen, near the surface. These two layers would not mix if the Baltic Sea were not so shallow (its average depth is 60 metres). During winter storms, the two layers become mixed and the deep water receives a sufficient quantity of oxygen to maintain life at the bottom.

Such was the situation until recently. Currently, however the sewage of continuously extending industrial enterprises and the domestic sewage of many big cities coupled with the agricultural effluent of fertilizers from fields is oversaturating the Baltic Sea with chemical nutrients. This results in intensive growth of phytoplankton near the surface. When it dies off, this phytomass sinks to the bottom, where there is not enough oxygen for decomposition to take place.

Similar changes are also observed in other regions of the world's oceans as a result of human activity. Observing these changes, biologists have the rare opportunity of observing over a period short processes which in nature occur over several millennia. For 20 million years, the Mediterranean and Red Seas were separated by a piece of land. The Mediterranean fauna was always similar to animal kingdom of the Atlantic Ocean, while inhabitants of the Red Sea resembled the fauna of the Indian Ocean. In 1869, the Suez Canal, the first water artery connecting the two seas, was constructed. It seemed that animals could easily migrate from one basin to the other, but for some reason, this did not happen immediately.

The average water level in the Red Sea is somewhat higher than in the Mediterranean. Therefore, when the ca-

nal was opened, there appeared a weak current from the town of Suez on the Red Sea coast towards Port Said on the Mediterranean Sea. Biologists expected many species of planktonic organisms and small fishes to migrate with this current. By 1929, only fifteen species had so migrated and no migration was observed in the opposite direction.

This migration was insignificant because there were two barriers. The first was the Bitter Lakes, whose bottoms had thick salt deposits (one lake contained almost 1,000 million tons of salt). When the lakes were isolated, salt covered with a thin layer of extremely dense and saline water remained still. But when the lakes were connected and the water began to Suez move along the canal salt began dessolving and water salinity in the Canal rose to 76 to 80 per cent. This proved too high for most animals inhabiting the Red Sea, although they were accustomed to a comparative high salinity (42 per cent). The other barrier was, strange as it may seem, low salinity. In the Port Said area, the water salinity was always lower than in other parts of the Mediterranean, as a result of the large inflow of fresh water from the Nile. Indeed, at the height of the Nile flood, water salinity near Port Said drops down to 26 per cent. Thus, animals which successfully overcome the first barrier perished in the other near Port Said.

Such was a situation in 1929. Since then the canal has been deepened and broadened several times: in 1963, its conveyance capacity became 50 per cent higher. Moreover, the salt in the Bitter Lakes has been mostly washed out by water running along the canal, and the water salinity in the lakes has dropped down to 43 to 46 per cent, approaching conditions of the Red Sea. Thus, one of the two barriers no longer exists. For the last forty odd years, the number of migrating animals through the Suez Canal has been nine times higher for the previous sixty years.

But this is not the end of the story. Since the Asuan dam has been constructed, much of the fresh water from the Nile is used for irrigation in Egypt and so sea salinity near Port Said does not drop at present, thereby eliminating the other obstacle. This must result in a still greater migration of living organisms from the Red Sea to the Mediterranean, until canal silting takes place.

Certain migrators from the Red Sea became acclimatized in the Mediterranean Sea and multiplied to such an extent that their commercial catching became possible, e. g. common shrimps, two crabs and several fish species.

For the time being, the inflow of living organisms from the Red Sea has caused no disturbances in the biological balance of the Mediterranean Sea. But sometimes the newcomers fit in better in the Mediterranean than in their previous habitat and their reproductian becomes so intensive that they violate the well-balanced life of the community which they joined. It is precisely this danger which was advanced by biologists as the strongest objection to the construction of a new canal at sea level through the Panama Isthmus. As far as the old Panama Canal is concerned, it is hardly possible for any animal to migrate through a system of sluices and, above all, through the fresh-water Gatun Lake. Construction of a new canal at the sea level could radically and swiftly change the picture.

The construction of the Asuan dam also affected sardine fishing. From time immemorial, this region was noted for sardine fishing, with the Nile delta as the centre. At the larva stage, sardine requires low-saline water; during the Nile flood therefore when coastal water salinity dropped, there was a lot of sardines. At present, there is no drop in

salinity, it remains at the level usual for the Mediterranean Sea (39 per cent), and sardines have disappeared almost completely.

Narrow straits connect the Mediterranean Sea with one more sea whose area is approximately equal to that of the Baltic — the Black Sea. Its average depth is 400 meters and its maximum depth in the centre of the basin is 2,211 metres. Only one sixth of the whole water mass of the sea is inhabited by representatives of marine fauna and only one quarter part of the bottom, by benthic organisms.

Like the Baltic, the Black Sea has a large inflow of fresh water from a whole series of big rivers. The salinity of its surface layers therefore is not high (about 18 per cent), while deep waters are much more saline. Vertical circulation here is very weak due to great differences in density between various layers. Surface waters in the central part contain the maximum amount of oxygen which they can dissolve, while at a depth of 100 metres its content account only for 5 per cent of the corresponding maximum value. A little deeper and one may get into a zone where the life of planktonic organisms is impossible; a little deeper again, the water becomes completely lifeless and the amount of dissolved hydrogen sulphide continually increases. The lifeless zone constitutes five sixths of the whole water mass. From a depth of 180 to 200 metres there is no life at all at the sea bottom; only anaerobic bacteria producing sulphurous compounds can exist there.

A weak mixing of the surface waters with deep ones results in an unpleasant phenomenon. As in other seas, a continuous inflow of mineral substances enters the Black Sea with river waters. And, just as in other seas, most of these nutrients sink to deep layers where there are no plants which can process them. But in most seas, due to vertical circulation, a considerable body of the substances comes back to the photic zone where algae utilize them. In the Black Sea, due to a weak mixing of water, most of the nutrients, accumulated at the bottom, have almost no chance of being processed by plants or animal organisms in the future.

There are two factors making the Black Sea as it is. The first is a larger fresh-water inflow from the Danube, the Dnieper and the Don. The inflow far exceeds surface evaporation, which results in a strong surface current through the Bosphorus. Through the Dardanelles, the Bosphorus and the Sea of Marmara, the Black Sea is connected with the Aegean Sea, belonging to the Mediterranean Sea basin. Water salinity and density in the Black Sea are generally much lower than in the Aegean Sea. This results in the other factor — a permanent inflow from the Aegean Sea of high-saline waters running under the desalinated waters flowing out of the Black Sea in the opposite direction. It is due to this countercurrent that the Black Sea has not yet become a fresh-water lake.

The saline/fresh water balance in the Black Sea basin was established as long ago as the end of the last great glacial period, i. e. 6,000 years ago. But at present, with the construction of dams and irrigation systems on the Dnieper, the Don and the Danube, the balance may change. Oceanographers expect that this will result in a sharp decrease of river fresh-water inflow to the Black Sea and in an increase in surface water salinity. Waters of different salinity levels will mix and bottom waters will be enriched in oxygen resulting in increased fauna life. The way for migration of animals from the Red Sea (which have reached the Mediterranean Sea) will be open and they will populate Black Sea waters.

Though such a prediction is shared by many researchers, there is another,

more dangerous possibility. When the salinity levels of surface and deep waters become equal, water mixing will intensify. Most nutrients accumulated at the bottom will rise to the photic zone to be utilized by phytoplankton.

This is quite enough to cause the outburst in the development of blue-green algae (as it was the case in Lake Erie in Canada), which may result in mass death of living organisms in the Black Sea coastal water. One can only hope that this will not happen [38].

CONSERVATION AND USE OF LAND RESOURCES

Level and Efficiency of Agricultural Land Use

The level of the world's agricultural land use, that is, the area of cultivated lands including highlands, is 11.7 per cent. The highest index of tillable lands is in Europe (excluding the USSR) — 30.8 per cent.

Some 40 per cent of the world's arable lands are within the zone of humid climate, where farming is possible without irrigation; nearly 40 per cent are within the zone of instable humidity, 15 per cent in the zone of semiarid climate, where the volume of agricultural production may be considerably increased by means of irrigation, expanding the acreage under cultivation and increasing crop yielding capacity. The remaining 5 per cent of arable land is within the arid zone where farming is almost impossible without irrigation. Thus, about 60 per cent of arable lands in the world are in need of irrigation [89].

According to the International Commission on Irrigation and Drainage (ICID), irrigated lands are to be found in over 100 countries. Their growth rate, especially during recent decades, has increased considerably. In the 19th century, average annual growth was of the order of 0.4 million hectares; in the first half of the 20th century, it rose to 1 million hectares and in the period 1960 to 1974 — to some 6.6 million hectares. Irrigated lands account for 12.8 per cent of the total area under cultivation; 80.6 per cent of irrigated lands are situated in Asia (excluding the USSR), due to natural and climatic conditions that predominate in this region [90]. India, China and Pakistan account for a great part of irrigated lands in Asia. The total area under irrigation in Europe is also growing and now reaches 13.7 per cent of the arable land area. In separate countries, irrigated lands make up a greater part of agricultural lands: in Afghanistan, Japan and Pakistan these lands account for 50 to 75 per cent of arable lands, in Bulgaria, Chile, Indonesia and Sudan — 20 to 40 per cent and in France, Greece, Italy, Spain and the United States they account for 7 to 15 per cent.

According to FAO, the acreage of irrigated lands in the world can be increased two to three times. There are nearly 947 million hectares which could be irrigated in the world (only 25 per cent of this area is), including 290 in Africa, 335 in Asia, 160 in South America, 80 in North America, 30 in Europe and 2 in Australia. By the year 2000, irrigated lands in the world will almost reach 300 million hectares. The annual rate of irrigated land growth in developing countries is 2.9 per cent, and that of dry lands — 0.7 per cent [91].

There is great potential for increasing the efficiency of land, especially in developing countries where the level of agricultural development is low. In industrialized countries, the process of

allotting arable lands for non-agricultural purposes is under way. In the United States alone, 2.5 million hectares were rezoned for construction between 1964 to 1975 [92].

On the whole, a policy aimed at improving land resources involved in agriculture requires: an increase in productive capacity of agricultural lands; the use of soil organisms to form fertile, erosion-resistant soils; a solution of the problem of drastic soil reclamation in all zones of agricultural crop cultivation; the all-around preservation of productive agricultural land and the complex rehabilitation of land affected by opencast mining; compensation for loss of productive agricultural land through introducing well-balanced crop rotation; the accomplishment of comprehensive soil-protection procedures including managerial and economic activities, agrotechnical and hydro-engineering methods and land reclamation and reforestation to enhance soil fertility; the removal of mineral waste from agricultural lands; the elaboration of a procedure for compensation of agricultural production losses in case of land allotting for non-agricultural purposes, etc.; and the control of pests and agricultural crop diseases which cause crop losses amounting to between 20 and 25 per cent of potential food crop yield.

Agricultural Management and Food Problems

At present, the gross volume of agricultural produce in the world does not meet human food requirements. In spite of the fact that 6.7 to 6.9 centners of grain crops are produced in the world per capita, nearly half of the world's population is suffering from malnutrition or does not have a well-balanced diet, and children account for 40 per cent of this.

One scenario of world economy development is illustrated in Table 30.

Table 30

Daily Food Consumption per Capita

Country and region	Kilocalories (thousands)		Protein (g)	
	1970	2000	1970	2000
Developed countries with market economy				
North America	3.2	3,2	96	100
Western Europe (high income)	3.0	3.2	91	105
Japan	2.4	3.2	71	117
USSR	3.2	3.2	92	108
Eastern Europe	3.1	3.2	93	108
Asia (with a centralized planned economy)	2.1	2.5	59	79
Developing countries with market economy				
Latin America (middle income)	2.4	3.0	60	86
Latin America (low income)	2.2	2.9	50	74
Middle East	2.0	2.9	53	92
Asia (low income)	2.0	2.4	52	66
Africa (arid zone)	2.5	2.5	72	78
Africa (tropical)	2.2	2.8	62	87

In the industrialized regions with a market and centralized planned economy, there is a leveling tendency in volume of daily food consumption at the level of about 3.2 thousand kcal and 100 to 110 grams of protein. In developing countries, the actual food consumption level per capita is rather low; nevertheless, this level is expected to increase up to 2.5 thousand kcal per day by the year 2000. In Latin America, the Middle East and in tropical Africa food consumption will almost reach 3 thousand kcal. It is also expected that the average daily protein consumption will increase from 50 to 60 grams up to 75 to 90 grams in most developing regions. Only one low-income area in Asia will fail to reach this level, though United Nations experts point out that certain progress will be observed there as well [93].

Table 31

Potential Reserves of Virgin Lands' Development (mill. ha)

Region	Total area	Agricultural lands		Forests	Areas of potential land development for cultivation	Areas of arable lands including potentially suitable lands for cultivation	Percentage of total area
		total	including arable lands				
I. Industrialized countries	5555	1860	660	1870	140-170	810	14.5
Europe (including the USSR)	2733	850	380	1050	70-80	470	17.2
North America	1971	500	230	740	50-60	280	14.2
Australia and Oceania	851	510	50	80	20-30	70	7.0
II. Developing countries	7838	2590	800	2170	610-650	1400	17.8
Asia	2753	970	460	540	100-110	560	20.0
Africa	3031	1040	210	640	210-230	430	14.2
Latin America	2054	580	130	990	300-330	410	20.0
The whole world	13 393	4450	1460	4040	750-820	2210	16.5

By the year 2000 some 80 per cent of the world's population will live in developing countries, a phenomenon that may aggravate the nutrition problem in these regions and its ensuing consequences. Population growth is, undoubtedly, a limiting factor in combating hunger and poverty. To provide the ever-growing population of developing countries with food resources requires a drastic reorganization of agricultural management which implies in turn sweeping changes in land use and economic activities in order to accelerate the growth rate of gross agricultural produce. The expansion of arable land (it should be doubled, reaching 400 to 440 million hectares) plays an important part within the framework of these measures.

The construction of the Rajasthan Canal, agricultural development of vast desert areas, the valley of Assam, improving and plowing pastures which are suitable for cultivation and other low-productive agricultural lands could result in a 35 to 40 million hectare increase in arable lands. Some 10 to 15 million hectares of virgin land are considered potentially suitable for agriculture in Indonesia. Some 100 to 120 million hectares of land are suitable for transformation for agricultural purposes in Asia.

Large reserves for the expansion of arable lands are concentrated in countries of Latin America. In Brasil, for example, with its total area of 851 million hectares, only 30 are used for cultivation. Another 100 to 150 could be cultivated. Amazonia occupies a considerable part of Brazil's territory and could provide food for 1000 million people, according to United Nations data. Argentinian pampas covering more than 100 million hectares are also considered to be a large reserve fund of food resources. Some 12.5 per cent of the total 240 million hectares of potentially arable land is actually used for agricultural purposes. Other countries of Latin America, including Bolivia, Colombia and Peru, have potential for increasing the acreage of arable lands. At least a quarter of the land in Latin America could be used for agricultural production.

According to calculations of V. A. Vashanov and P. F. Loiko [42], agricultural lands in developing countries

Table 32

Farm Crop Yields (centner per ha) in Countries of the World (1972)

Country	Wheat	Rice
Albania	15.6	34.0
Algeria **	7.4	25.5
Angola	13.0	15.9
Argentina ***	13.4	—
Bangladesh	—	17.0
Belgium *	40.8	—
Brazil ***	10.0	—
Bulgaria	37.3	—
Canada	16.8	—
Chad	15.2	4.5
China	—	26.0
People's Democratic Republic of Korea	5.3	54.7
Denmark *	48.0	—
Egypt **	31.0	53.9
Ethiopia	8.1	—
Federal Republic of Germany *	42.3	—
France *	36.5	—
Gambia	—	12.0
German Democratic Republic *	41.7	—
Greece	19.6	50.6
Hungary	30.9	—
India	11.3	15.4
Indonesia	—	17.6
Islamic Republic of Iran ***	7.0	28.2
Italy	24.7	40.9
Japan	23.1	58.5
Kenya	16.9	42.8
Lao People's Democratic Republic	—	8.7
Libyan Arab Jamahiriya **	6.6	—
Mali	—	10.0
Mexico ***	27.9	—
Morocco **	10.9	15.4
Mozambique	10.0	—
Netherlands *	44.4	—
Niger	11.7	7.3
Nigeria	—	17.9
Pakistan	11.9	13.9
Peru ***	9.6	—
Philippines	—	12.3
Poland *	24.7	—
Portugal	9.1	—
Romania	23.9	—
Senegal	—	6.6
Spain	12.7	55.7
Sri Lanka	—	18.6
Sudan	11.4	11.7
Sweden *	42.5	—
Tunisia **	6.3	—
Turkey ***	12.8	—
United Kingdom *	36.6	—
United Republic of Tanzania	14.0	11.9
United States	21.9	—
Yugoslavia	25.2	—
Zambia	20.0	13.5

* — 1966. ** — 1971. *** — 1970

may be increased by 610 to 650 million hectares, and plowland may be expanded up to 1,400 million hectares. The estimated acreage of plowland expansion in the Europe region, excluding the United States, Canada and Israel, is about 80 million hectares, another 60 may be developed in Canada and the United States and 30 in Australia and New Zealand.

It is quite possible to increase agricultural land area by 800 million hectares and to expand the acreage of plowland up to 16.5 per cent of land in the world, thanks to advances in science and technology, taking into account development peculiarities of individual countries. This would result in an increase of almost 50 per cent agricultural produce (Table 31) [42].

Level of the Agriculture Development and Increasing of Soil Fertility

The exploitation of virgin land resources in developing countries is an important, but not a decisive precondition to meet food needs. The general growth in the level of agricultural production

and increasing of soil productivity and crop yields by introducing up-to-date agricultural practices are of paramount importance in solving this problem.

It has been estimated that doubling the average agricultural crop yield would mean that the average demand for plowland per capita in the world is 0.2 hectares. If the world's population reaches 6,500 million by the year 2000, then 1,500 million hectares of plowland will be required, which approximately corresponds to the acreage of arable lands at present.

The efficiency of yield increase is becoming particularly evident with the advent of the 'green revolution' or the use of new seed varieties and the large-scale introduction of modern field management favouring the breeding of high-yielding varieties of wheat, first in Mexico where the wheat yield had increased from 8.8 to 27.2 centner per hectare for the period 1952 to 1972. From the middle of the 1960s, Mexico stopped importing grain and at present is exporting nearly 1 million tons per year.

Improved varieties of Mexican wheat were widely distributed in India, Pakistan and the Philippines, and in 1970 Pakistan became self-sufficient in wheat and 1971 saw a record grain crop yield in India.

In 1970 Dr. Borlaug was awarded a Noble Prize for breeding high-yielding varieties of wheat, a comprehensive complex of measures, aimed at increasing the yield of farm crops and improving field management, irrigation and fertilizer utilization for the purpose of increasing grain crop production called the 'green revolution' took place. However, the 'green revolution' failed to live up to the hopes and expectations associated with its advent. In spite of successes achieved by the 'green revolution', the general level of agricultural production in the developing countries is very low, and the data concerning crop yields of wheat and rice testify to this (Table 32).

Such a situation can be explained to a large extent by the general backwardness of agriculture, land cultivation by hoe, burning of shrubs and herbage, soil erosion and degradation, insufficient use of mineral fertilizers, unsatisfactory use of irrigated lands, low level of agricultural management, backward agricultural machinery and implements, etc.

At the same time, there are considerable means available for increase in productivity in developing countries, more general use of high-yielding farm crop varieties, soil improvement, irrigation, better use of mineral fertilizers, observance of planting and soil cultivation periods, etc. The potential for increasing soil fertility is shown in the fact that, although the world average wheat yields is 15 centners per hectare, and maize yield 20 centners per hectare, the highest yield of the same crops reach 70 and 120 centners per hectare, respectively. Therefore, the main preconditions for increasing the efficacy of agricultural production are the introduction of high-yielding farm crops, mechanization, chemicalization and the intensification of production on the basis of increasing the volume of investments in agriculture [42].

Water and Wind Erosion of Soil

One of the reasons for the reduction in arable land is intensive water and wind erosion which is caused, mainly, by an ever-growing human impact upon soils. Soil erosion has become a real scourge for farming in spite of vigorous activities to localize it. Between 50 and 60 per cent of the land of West European countries is affected by erosion and up to 75 per cent of land in the United States. By the 1960s, soil eroded and destroyed by erosion accoun-

ted for nearly half of the land under cultivation and fell under the category of 'dead' land not subject to rehabilitation. In the 1970s, the annual washoff of fine earth by water flow averaged nearly 1 cm, increasing up to 2 cm in certain areas.

Soil destruction is manifested in washoff and washout, in the formation of creeks, ravines, dust storms and other unfavourable phenomena. Some 31 per cent of land is affected by water erosion and 34 per cent by wind erosion. Surface soil washoff annually reaches nearly 134 tons per square kilometre. About 60,000 million tons of soil material is washed off annually into the world's oceans, while in the past soil washoff did not exceed 3,000 to 8,000 million tons. Nearly 430 million hectares of land has been destroyed by erosion in different countries. With the erosion rate at the present level, the world may lose up to 1,000 million hectares by the year 2000; nearly 2,000 million hectares have been already lost in this way [43].

The available statistics indicate that about 38 per cent of pasture in the United States is losing soil at an inadmissible rate. The total estimated surface soil washoff cost at least $ 25,000 million [95]. A specialized agency supervises soil protection activities in that country. According to its reports, soil protective treatment was carried out in 1979 in an area of 22 million hectares.

Initial progress has been made in rendering assistance to tropical and subtropical countries to combat erosion. Fourteen new species of woody-shrub and grass plants were submitted to individuals and companies; 3.6 thousand hydrological forecasts have been made in Western United States. The soil conservation agency has given assistance by supplying water to pastures in arid areas. Pasture rotations have been recommended as soil protective measures. In 1979, 10 million hectares of pasture were protected from erosion. Research into soil humidity has recently been undertaken, to be used as the basis of drought forecasting. In accordance with the Soil Conservation Program for the Great Prairies, agreements on soil protective cultivation of 1.2 million hectares of plowland have been concluded with farmers [96].

In the USSR, the annual soil losses are 4,500 million tons (taking into account that soil washoff per hectare is equal to 30 tons). Due to erosion, the country's agriculture gets 6.4 million tons of fertilizers less, and the total grain shortage from the slope plowland is 32 million tons [97]. The destructive impact of wind erosion in the USSR is observed in the south of the Ukraine, Kazakhstan, the Lower Volga region, the plain areas of the North Caucasus, and Central Asia, the Buryat and Bashkir Autonomous Soviet Socialist Republics, Khakass Autonomous Region. Water erosion has a detrimental effect upon pasture productivity and soil fertility, resulting in water body silting and ravine formation in the Central black-earth regions, Rostov and Saratov regions, in the Ukraine, Moldavia, and North Caucasus and the Middle Volga area. Therefore, a comprehensive purposeful programme on the use of field management, forest improvement and hydrotechnical means of soil conservation to control water and wind erosion is being carried out in that country. Soil protective crop rotations with the alternation of crops and fallow lands, growing of dense vegetation shelterbelts, grassing of heavily eroded lands, arrangement of buffer strips of perennial grasses, snow retention, fixation and afforestation of sands, growing of field windbreaks, subsurface tillage with the stubble left on the field's surface, etc. have proved highly efficient and are practised on a large scale.

Other countries are also affected by

Table 33

Fertilizer Consumption per 1 ha of Arable Land and Total Agricultural Area per Capita in Latin America in 1970-71, kg

Country or region	Arable land			Total	Agricultural land			Total	In terms of $P_2O_5K_2$ per capita
	N	P_2O_5	K_2O		N	P_2O_5	K_2O		
Mexico	18.4	5.4	1.1	24.9	4.3	1.3	0.3	5.9	11.7
Cuba	44.3	25.7	40.6	110.6	26.4	15.3	24.2	65.9	47.1
South America (total)	7.1	7 8	5.1	24.9	1.3	1.3	0.9	3.4	8.8
Argentina	1.6	1.5	0.3	3 4	0.2	0.2	—	0.4	3.6
Bolivia	0.2	0.3	—	0.5	—	0.1	—	0.1	0.3
Brazil	0.3	12.6	10.3	32.2	2.0	2.7	2.2	6.9	10.2
Chile	9.3	22.0	3.1	34.4	2.7	6.5	0.9	10.1	16.2
Colombia	12.2	11.6	9.9	33.7	2.9	2.7	2.3	7.9	8.4
Ecuador	4.7	2.5	1.7	8.9	3.0	1.6	1.1	5.7	5.6
Paraguay	2.6	3.5	3.4	9.5	0.2	0.3	0.3	0.8	3.8
Peru	35.5	4.6	1.8	41.9	3.3	0.4	0.2	3.9	8.8
Surinam	37.8	6.7	4.4	48.9	32.7	5.8	3.8	42.3	5.5
Uruguay	6.8	16.0	3.0	25.8	0.9	2.0	0.4	3.3	17.5
Guyana	8.1	1.7	2.5	12.3	2.0	0.4	0.6	3.0	13.1
Venezuela	1.3	0.8	1.2	3.8	0.8	0 5	0.7	2.0	6.3

determinal after-effects of erosion. For example, in Bulgaria 72 per cent of arable lands are affected by water erosion and 40 million cubic metres of fine earth are annualy lost from arable lands (to equal to 60 million tons of fertile soils). Some 2 to 4 per cent of humus, 1.1 to 2.9 per cent of phosphorus and 0.7 to 2.2 per cent of useful soil moisture are annually lost due to erosion in Romania in erosion-affected soils of Central Plateau of Moldova and Dobrogea. There are 2.3 million hectares, i. e. 30 per cent of farm lands, exposed to various degrees of erosion in Hungary, while 2 million hectares of agricultural lands in Czechoslovakia are exposed to wind erosion. The surface erosion area covers 13 per cent of the territory of Poland.

From 4 to 6 thousand hectares of sugar beet plantations in peat and sandy soils are annually exposed to wind erosion in the United Kingdom from March to June. In central years, up to 50 per cent of these areas are replanted several times. Some 70 thousand hectares of reclaimed peat soils used in field cropping, 6 thousand hectares of dune sands (where tulips are grown) and 2 thousand hectares of sandy soils used for asparagus cultivation are exposed to wind erosion in the Netherlands. The estimated average loss from wind erosion in plant growing and vegetable growing production is nearly 10 million Dutch guilders.

In India 4.2 million tons of nitrogen, 2.1 million tons of phosphorus, 7.3 million tons of potassium and 4.3 million tons of lime are annually lost from the soil with farm crops due to erosion. Countries in Asia, Africa and Latin America are suffering great losses due to soil erosion. Only 19 per cent of Mexican territory may be considered as not exposed to erosion; at the same time, 24 to 26 per cent of lands are exposed to moderate and progressive erosion, 16 per cent have turned into barren lands, and urgent measures must be taken to prevent initial erosion in 15 per cent. The percentage of erodible lands is 22 per cent in Ar-

gentina, 20 per cent in Brazil, 55 per cent in Chile, 50 per cent in Colombia, 43 per cent in Peru, 15 per cent in Uruguay and 64 per cent in Venezuela.

Permanent crop predominance in rotation in a number of countries leads to considerable soil depletion. Thus, in Perú the estimated average annual soil washoff is 1,501 tons per square kilometre. Some 200 thousand tons of nitrogen, 90 thousand tons of phosphorus, and 50 thousand tons of potassium are washed off annually from soils used for grain and oil-bearing crops in Argentina. The volume of applied mineral fertilizers does not compensate these losses (Table 33) [98].

Marshland Drainage

Bogs are excessively wet ground covered to a certain depth by a peat layer which is a power-generating resource and, at the same time, is used as a fertilizer in agriculture. Other excessively wet land areas, where the peat layer depth does not reach the same level with appropriate vegetation, are considered marshlands. Bog formation takes place mainly due to bogging of forests, sites after forest fires, meadows, overgrowing and overpeating of various small and middle-sized water bodies. Bogging is particularly rapid in flat watersheds. Under climatic conditions of tundra, forest-tundra and forest zones bogs are formed in watersheds and in river valleys. In the forest steppe and steppe zones bogs are mainly situated in more or less deep depressions of the terrain, river flood plains and sandy river terraces. A considerable number of bogs results from water body bogging due to vegetation growth and mechanical filling.

Depending upon formation types, water régimes and plant cover, distinctions are made between low level, transitional and high bogs. Low-level bogs are situated in river valleys and fall under two groups: bogs of depositon feed which are particularly rich in mineral salts brought by alluvial (river) and delluvial (rain and snow) waters and bogs of ground water feed. Bogs of deposition feed are formed in river flood plains and along lake banks. In a moderate climate, there are forest bogs and grass bogs. Transitional, or intermediate, bogs have moderate mineral feed. High bogs are farmed, as a rule, in watersheds, fed by atmospheric waters and are the least rich in mineral salts.

Most extensive marshlands are situated in Asia, Europe and America. The development of bogs and marshlands is a large resource for expanding areas under crops and land use improvement. Swampy soils are rich in acids, nitrogen and other organic matters. The yield of grain crops reaches 30 to 40 centners per hectare, and that of potato — 300 to 400 centners per hectare in drained marshlands. The productivity of forest plantations is sharply increased in drained marshlands.

There are million hectare of bogs and marshlands in the USSR. In western regions and in the Polessie zone of the Ukraine, they cover an area of 2.637 thousand hectares. One hectare of drained land may produce up to 5 to 6 thousand feed units on the average per year, while one hectare of natural meadow lands produces only 500 feed units.

Between 1981 and 1985 it is envisaged to carry out the drainage of swampy and excessively wet ground in the USSR in an area of 3.7 to 3.9 million hectares of which 1,120 to 1,200 thousand hectares are in the Ukraine and Byelorussia. This will provide an important source of increased agricultural produce. This large-scale drainage operation is closely linked with a comprehensive ecological and economic approach to the construction of water supply and distribution systems. Such an

approach requires the assessment and analysis of capital investment efficiency, a more detailed study of problems of small river shallowing and losses of accumulating properties by bogs, changes in soil formation, flooding, maintaining the optimal water and air soil régime in drained areas, the decline in bird population and more effective use drained lands under farm crops.

The problem of eliminating in designing and constructing large-scale drainage systems, which considerably reduce (and in a number of cases minimize the advantages to be derived from the improvements) is of no less importance.

For example, hydromelioration construction and development of virgin lands in a number of Polessian districts (USSR) led to substantial ecological disturbances. Annual precipitation was reduced by 10 to 11 per cent, water-storage of snow cover during the snow-melt period was reduced by 35 per cent, number of dry days with a relative air humidity under 30 per cent in the warm period of the year was more than twice as large, and the shortage of air saturation with moisture was increased by 9 per cent in the Sarny, Novograd-Volynsky and Shchors districts. Reclamation of bog and marshland caused a decrease in the ground water level in neighbouring areas and deterioration in the general condition of soddy podzolic soils, which resulted in a local dieback of young forest plantations, thinning of natural herbage, etc. The general condition of water bodies and water courses deteriorated, the number of valuable species of local fauna decreased and the fish-production capacity of lakes diminished [99].

It is urgent to consolidate and set up new environment-oriented territories and objects, to use up-to-date methods of land reclamation in order to maintain an ecological balance. From this viewpoint, closed-circuit water reclamation two-flow systems, the polder process of drainage, the use of immersion electric pumps, the construction of water wells, the construction of vertical drainage and use of closed drainage in objects with a flat terrian are of a promising and long-term nature.

The advantages of two-flow regulation lie in the fact that this system provides favourable conditions for optimization of water and air soil régimes and utilization of nutrients entrained by drainage waters from the soil, prevents 'chemical' pollution of open water sources to a considerable extent and provides possibilities for water and salt regime control. Irrigation by accumulated drainage waters returns 20 to 70 kilograms of nitrogen, 15 to 20 kilograms of potassium, 50 to 150 kilograms of calcium and 300 to 600 cubic metres of water per hectare of agricultural land [100].

The advantages of polder drainage in comparison with the gravity flow method are associated primarily with avoiding the expensive and labour-consuming work involved in river-water intake regulation. It considerably reduces the damage done to commercial fishery, makes it possible to use runoff for different economic purposes, including soil humidification, and causes minimal disturbance to the established hydrological conditions of river beds.

Recultivation, Soil Conservation and Protection

Recultivation of agricultural land destroyed by strip and underground mining of mineral resources and of land occupied by refuse dumps affects the quality and volume of land involved in agricultural production.

Highly effective strip mining of raw materials results in considerable destruction of vast areas of the Earht's surface along with disturbances in hy-

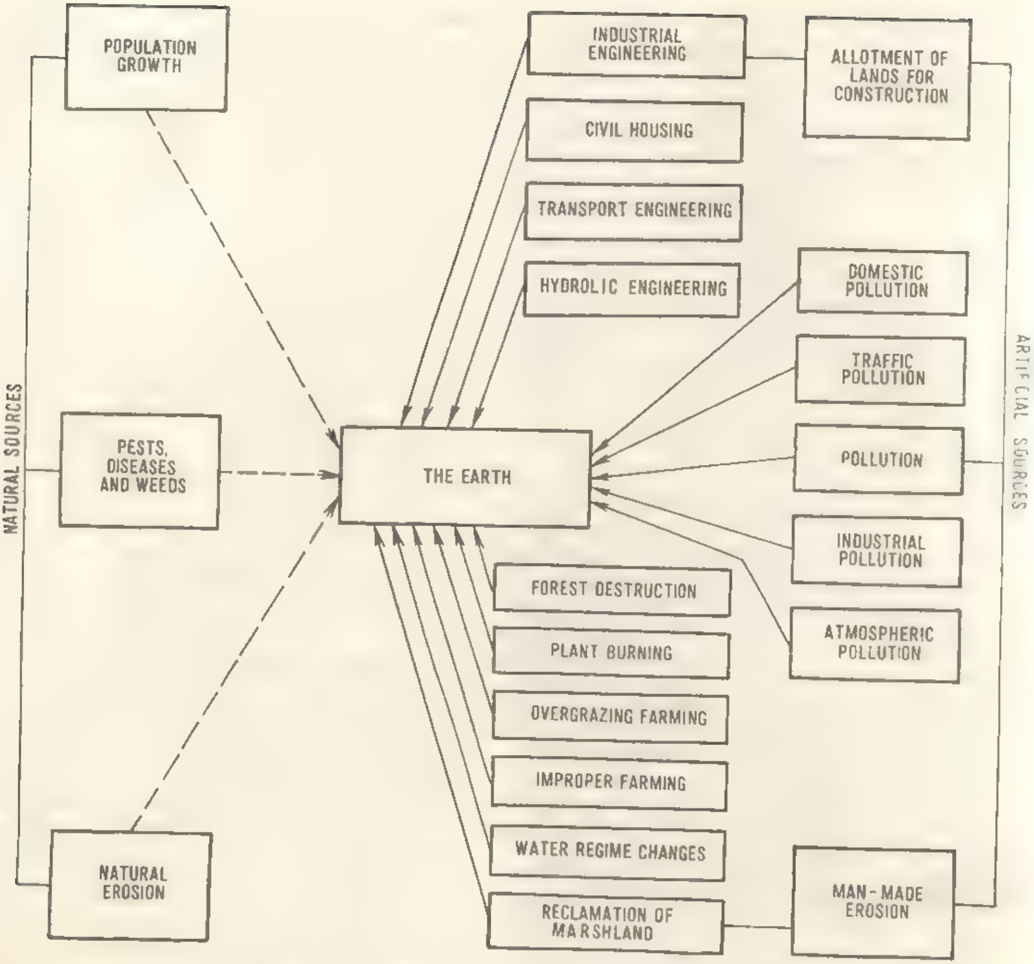


Fig. 19. Basic factors influencing land use.

drological and geochemical soil composition. The newly-formed landscape and unfavourable soil conditions turn the areas of strip mining into 'industrial deserts', As a result of mining, 4.8 thousand hectares of strip-mining land are annually treated in the United Kingdom and 6.1 thousand hectares in the United States. The total area of such lands covers 58 thousand hectares in the United Kingdom, and 5.2 million hectares in the United States. In Poland (according to 1975 data) there were 91.7 thousand hectares to be rehabilitated, including 69.4 destroyed due to strip mining, and 22.3 due to peat extraction. Strip-mining land losses in the German Democratic Republic reach 2.5 to 2.7 thousand hectares.

To rehabilitate soil fertility of strip-land, a complex of mine engineering, ameliorating, biological and other work is needed. This problem is of particular importance due to the fact that the strip mining's share in mineral resources production is steadily increasing.

The use pattern of land to be rehabilitated depends upon a number of fac-

tors, including surface contour, the percentage of rocks, the quantity of sulphides and other minerals which are toxic to plants in the stripped rocks and the quantity of lime, phosphorus and potassium which are necessary for plant growth. But soil acidity, the most important condition for biological recultivation, is the dominant factor.

The highest forms of agricultural production for which strip-mined lands may be rehabilitated are cereals, fodder grasses and orchards. To meet these purposes, the soil surface under rehabilitation is leveled in order to allow for the large-scale use of agricultural machinery.

In most vast dump areas, trees are planted as a function of the soil's chemical composition. Another way of soil surface rehabilitation is associated with the establishment of recreation zones, lakes and game and fishing reserves on the surface of open pit spoil heaps. Modern concentrating mills and integrated dressing plants require the removal and stockpiling of industrial waste. Slag storehouses wich are necessary for the waste stockpiling not only consume considerable land areas, but also cause great damage to adjacent areas by overhumidifying and bogging them up.

In spite of the vital importance of strip-mined land rehabilitation, their recultivation is being conducted very slowly, because soil fertility regeneration requires the use of specialized field management procedures, large investments and an elaborate economic system of control and incentives.

Protection of Land Resources Against Pollution

Like the atmosphere, the Earth is subject to natural and man-made impacts (Fig. 19). In the course of the planet's development, mineral and organic substances maintain the natural balance and do not affect geochemical processes. Anthropogenic soil changes and destruction, on the other hand, have detrimental after-effects and cause, initially, a reduction in the productivity of agricultural land.

In 1969 alone, losses of the world's harvest caused by farm crop pests and diseases were 1,390 million tons, or 386 kilograms per capita. Thus, measures of control are vital to an increase in crop production.

However, the use of chemical plant protection has a counter-productive aspect. The misuse of chemical plant protection, notably pesticides, may lead to unfavourable after-affects. The cumulative residual toxicity of pesticides is particularly hazardous. Applied to upper layers of the coil, pesticides penetrate, one way or another, into animals, plants and people.

For the last decade, the production and application of pesticides in the United States for example, has considerably increased. In 1978, nearly 0.5 million tons of pesticides, including 300 thousand tons for agricultural purposes, were used. With more than 1,200 active chemical agents in the environment, ecologist's anxiety about their impact on human health is well-founded.

A group of experts from the Cornell University analyzed the advantages of using pesticides in agriculture and estimated yield loss in case of their rejection. Calculations showed that without pesticides, yield losses in monetary terms would be increased by 5 per cent in comparison with losses caused by agricultural pests. Losses due to pests, which reach 33 per cent at present, will increase up to 42 per cent of estimated yield in monetary terms. Caloric value of agricultural produce will be reduced, on the whole, by only 1 per cent and of food by 4 per cent. The rejection of pesticides, in their opinion, will not lead to the reduction of food output [101].

The use of DDT and its derivatives is particularly hazardous. Soil tests in Norway, where DDT was widely used

for fruit crop pest control from the end of the Second World War until the imposition of a ban in 1970, showed that the rate of DDT application was relatively high in comparison with other areas of fruit growing. Residual toxicity in organisms of human beings and cows and in soil, was from 5 to 100 times higher than in control areas.

The application of pesticides and fertilizers is far from being the only source of land resource pollution. Industry, motor transport, discharged waste, domestic sewage and atmospheric pollution account for the lion's share of the pollution volume. Because of these, the soil is saturated with iron, mercury, lead, copper, zinc and radioactive elements. The world's annual production of iron is 500,000 million tons; irreversible losses due to corrosion and attrition amount to 25 per cent on worldwide scale.

The world's mercury production is 8.8 thousand tons per year; half of this is lost in the course of utilization. Uncontrollable mercury emmission on a world-wide scale reaches approximately 4-5 thousand tons per year, almost equal to that amount of mercury extracted from rocks for the same period. During the last twenty-five years, some 30 thousand tons of mercury have entered the biosphere from the United States alone [102].

Despite the adoption of strict rates of mercury application for the agricultural crop pest control, its preserve in soil and plants exceeds by far the level of concentration recommended by WHO (0.05 mg/kg). For example, in the vicinity of the mercury mine in Almadence (Spain), mercury content in soil was 0.5-260 µg/g, the highest concentration was found close to the mine. A substantial fraction of total Hg in control soils (2.3 µg/g) and in soils in the vicinity of the mine (97 µg/g) was associated with dense minerals, mainly cinnabar. The mercury content in underground parts of alfalfa was ten to twenty times higher than the world average Hg concentration in grasses [103].

Motor car exhaust and gases from industry are one of the sources of soil pollution with lead. Tests for benzapyrene in forty-nine regions of Poland showed that its concentration in potato tubers was within a range of 0.538-28.74 µg/g of dry matter. The level of benzapyrene content in 12.5 per cent samples out of 112 assays was 1 µg/kg of dry matter, in 54.5 per cent — 2 µg/kg, and in 85.5 per cent — 4 µg/kg. When the level of benzapyrene content in soil was 60 µg/kg, there were indication of sharp increase of this compound in potato tubers (13,433 µ/kg) [104]. In Bulgaria, in the area neighbouring to lead and zinc smelters, the lead concentration in soil was within a range of 29 to 400 mg/kg, and in the affected zone of a storage battery plant the same index ranged from 140 to 510 mg/kg. The background lead content in inpolluted areas was 12 to 15 mg/kg. The growing of farm crops in lead-polluted soil areas is fraught with danger of toxic agent accumulation in crop product output. Thus, the lead content in alfalfa was 96, in maize — 4.3, and in cabbage leaves — 10 mg/kg [105].

A considerable amount of metal may be accumulated in soil in agriculteral fields under sewage irrigation. In Melbourne (Australia), for example, the increased content of nitrogen, potassium and heavy metals was detected in irrigated fields. The upper 2.5 cm layer appeared to be especially polluted. Changes in the content of chemical elements in soils also affected plants by increasing the percentage of zinc, copper, cadium, chromium, cobalt, potassium, nikel and magnesium. Fodder crop pollution carries the threat of cattle disease in case of animal grazing in sewage-irrigated fields [106].

The volume of soil pollution is in-

creased by industrial discharge into the atmosphere and by waste stockpiling. For instance, dust and gaseous waste of concentrating mills of the industrial 'Belaruskaly' amalgamation contains hydrogen chlorine, sulfur dioxide, and carbon and nitrogen oxides as well as other toxic agents which enter the soil and cause salinization of most fertile arable lands. Salinization and air pollution with salt dust and toxic gases can reduce crop yields by 30-50 per cent, especially in the vicinity of discharge sources. Such farm crops as buckwheat and potato sensitive to chlorine are most affected by soil pollution [107].

In the Donetsk industrial region (USSR), the stockpiling of industrial waste of by-product coke plants containing phenols, cyanides, rhodanides, chromium, zinc, copper and other substances also favours toxic agent accumulation and soil pollution in industrial dumping areas. When phenol concentration is up to 20 mg/kg, chemical compound migration along the soil profile was detected: fifteen days later phenol was found at a depth of sixty centimetres and its quantity was 1.3 to 1.5 times higher than that of the control content; that of chromium, copper, nickel and zinc at the same depth was 1.2 to twice as high. At a distance of 300 metres from industrial damping grounds and 200 metres from refuse heaps the process of soil self-purification is inhibited and there are indications that chemical agents penetrate into consumed food products [108].

Soil pollution with acid atmospheric precipitation which assumed considerable proportions in North America, in particular in the 1950s to 1970s, arouses an ever-growing anxiety. This phenomenon is closely associated with acid oxide release into the atmosphere caused by fuel burning. The annual sulphur dioxide release into the atmosphere reaches $3.8 \cdot 10^8$ tons in the United States, and $6.5 \cdot 10^6$ tons in Canada. The ratio between derivatives of sulphuric and nitric acids in precipitation is 60 to 70 per cent and 30 to 40 per cent. The impact of acid precipitation upon soil becomes apparent in the inhibition of soil microorganism activities. Potentially toxic elements, including aluminium and manganese, entering the soil through acid precipitation, have a detrimental effect upon plant roots and their absorption of nutrients [109].

Basic measures of soil pollution control include: elaboration of production techniques in industry, ration soil cultivation practice, strict observance of set rates, terms and methods of pesticide and chemical improvement application, taking into account physical and chemical soil properties. Land resource pollution control requires a well-adjusted documentation system dealing with the basic types of pollution as well as branches of industry.

Desertification Problems

The analysis that has been made of arid zone desertification has focused attention upon the general underestimation of this phenomenon. In Chad, for example, in the period 1954 to 1974 the continuous plant mantle was reduced by 32 per cent, and soil erosion process was considerably intensified. A similar situation holds of Sudan, Mali, the southern part of Tunisia and certain other countries. A distinction must be drawn between desertization and desertification — the latter includes plant degradation and soil erosion within any natural zone as well as man-made ones. Desertization is the area expansion of typical desert landscapes within arid zones — increasing of spaces covered by sandy dunes, denuded desert surfaces, etc. It actually brings about the formation of almost non-productive lands, and the agricultural use of these lands gi-

ven the general aridness of the terrain is next to impossible. The natural situation in desertification areas is a major prerequisite for their economic potential rehabilitation.

It is of great practical interest to study world desert evolution with a view of making a distinction between the so-called climatic (genuine) deserts and those that have emerged due to human activities, for example, in Mesopotamia. Climatic deserts during the last millennia tend to a peripheral expansion; some climatologists discover sings of a global tendency of the planet climate to a general increase in aridization and predict much harder times for mankind in this respect. Other experts are of the opinion that there is a certain cyclicity in atmospheric precipitation, still not revealed. In the northern part of the Sahara, for instance, there were droughts in 1920 to 1925, 1944 to 1948, and 1959 to 1961, and in its southern part, correspondingly, in 1913 to 1916, 1940 to 1946 and 1969 to 1973.

The impact of human activities upon nature in arid zones is of particular importance in desertization assessment. In these zones of Africa and Asia, the population is growing annually by 2 to 3.5 per cent, i. e. it doubles every twenty to thirty-five years. Desertification expands at particularly fast rates in the case of plant cover destruction, and in the above-mentioned zones the reduction of grazing lands due to arable land expansion, to say nothing about overgrazing in cattle-breeding areas, is observed almost everywhere. In Sudan alone, in the arid areas of Kordofan and Darfour, arable lands were increased by 1.2 million hectares with a 75 per cent crop yield reduction in 1960 to 1973. The situation is the same in Mali.

According to FAO data, 55 per cent of the cattle stock in Africa are concentrated in arid and semiarid zones: the total number increased by 70 per cent on the average from 1950 to 1973. Population and stock density in most arid areas of Africa exceeded the limits of natural ecosystem stability as a result. In a number of cases, desertization has led to irreversible unfavourable changes in the environment, and a search for the control of this phenomenon as well as attempts to rehabilitate the economic potential of desertizated land areas are therefore under way. Nevertheless, most attempts are either unsound of fruitless from the scientific point of view. Sporadic attempts to set up forest belts around and inside deserts and desertizated areas in arid zones can hardly make a considerable improvement to the existing climatic situation. Irrigation itself, which has been used for a thousand years in arid zones, cannot stop the desertization; in many cases, it has already promoted its expansion, mainly in marginal irrigated areas.

Successful desertification control is only possible in the context of realistic assessments of ecological factors, and an approach which combines due respect for human impact upon arid ecosystems. A correct socio-economic policy in arid zones, namely, population and stock density control and development of an economy additional strain on the ecological systems are also very important [110].

It was from this standpoint that a special plan of action on desertification control providing for strict regulation of the socio-economic problems of agriculture and water management from the point of view of environment-oriented methods of land resource exploitation in the arid regions of the world was endorsed at the United Nations Conference on Desertification in Nairobi (Kenya, 1977). According to the Conference, a fund of $ 400 million is needed annually in order to stop the desertification process. The rehabilitation of barren lands, at the present pace of desert advance, will require $ 1,500 million per year for twenty years [111].

The Nairobi Conference proposed six international projects: a green belt in North Africa; a green belt in the Sahara, a programme of joint cattle management in the countries of South Sahel; a water supply programme for North Africa and the Arabian peninsula; and projects on desertification monitoring in South-West Asia and South America. In spite of all these proposals, the progress acheived in desertification control has been insignificant. Even though forest are preserved on 20 per cent of the land surface and 40 per cent of this forested area are not subject to human impact, in South America, Asia and Africa nearly 11 million hectares of forests are felled annually without any effort at reforestation. The main reasons for forest destruction is unbalanced agricultural land expansion and the use of timber both as a fuel source and for other purposes.

According to available statistics, 40 per cent of tropical rain forests in the world have been destroyed, and by the year 2050 will be completely depleted if their destruction continues at the present rate. Territories of insufficient humidity occupy 30 per cent of the land, with 700 million people living there. Human activities have already led to desert expansion in areas which are approximately equal to the area of Brazil. Regular soil cultivation is virtually impossible on these lands, which detrimentally affects world food production, including that of meat, grain and fibre vegetables.

IUCN has analyzed the implementation of the plan of action endorsed at the Nairobi Conference and shows its basic shortcoming, mapping out concrete measures to increase effective desertification control. Among these, the most important: involve overcoming political disagreements and the unification of efforts by developing countries; the adoption of local measures in developing countries encouraging the return to nomadic cattle-breeding; the participation of industrialized countries in financing desertification control projects through the United Nations; working out and accomplishing national desertification control programmes in close interrelationship with land and water use programme; and the development of scientific research and training of personnel.

CONSERVATION AND USE OF BIOLOGICAL RESOURCES

Use and Reproduction of Forest Resources

Forest ecosystems have a positive impact on all enviromental components. Forests accumulate solar energy, participate in gas exchange, climate formation, and the hydrological cycle, and create necessary conditions for life on the Earth. They exert a direct impact upon wind and water conditions, and protect soil and crops. A valuable source of raw material and food resources, they also have great recreational and aesthetic significance.

The declaration adopted by the seventh World Forest Congress (Argentina, 1972) noted that forests had multifold significance and that the use of their resources considerably affected the human environment, and meeting human needs in term of food, water and dwelling.

Timber is the chief industrial resource of the forest (see Table 34) [94]. In 1970, developing countries accounted for 54 per cent of world wood output, which was increasing annually by more than 28 million cubic metres. Developing countries are the main suppliers

Table 34

Dynamics of Wood Output in the World

Groups of countries	Used forests 1971	Wood output, mill. m^3			Wood output in 1970, % to 1950
		1950	1960	1970	
UN Member State's	1500.0	1307.4	1900.7	2374.5	182
particularly socialist countries	438.6	312.5	592.8	633.5	202
developed capitalist countries	386.9	624.0	725.5	799.2	127
developing countries	674.5	371.9	582.4	941.8	254
Europe (not including USSR)	123.0	272.0	317.0	332.0	121
USSR	191.5	282.7	308.9	336.7	118

of wood in the economy and it is expected that by 1990 they will provide 50 per cent of the entire wood output [44]. Considerable changes have taken place in wood utilization. From 1960 to 1970, lumber output increased by a factor of 1.2, veneer 2.1, plates 3.2 and cellulose, wood pulp, paper and paperboard 1.7. Lumber is the most important among all wood products.

The following are basic lines for reforestation: waste-free cutting; the use of barren lands, ravines and cutting areas for forest cultivation; taking due measures to reduce wood loses, improvement of forestry; the use of chemicals and fertilizers; reforestation, restoration and cultivation of valuable wood species, and protective afforestation; improvement of forestry seed collection and storage; use of forest hydroreclamation; breeding and genetic inspection of forests; creation of hybrid forms and acclimatization of forest cultures; construction of new and reconstruction of existing enterprises on the basis of forest conservation technology; forestry development on the basis of new equipment for lumbering and logging; a complex approach to conservation and reproduction of forest resources taking into account the rational use of water bodies and soils, and programmes to avoid land desertification; an economic incentive system for reforestation coupled with the revision of national forestry legislation; the improvement of forestry organization; the development of national programmes of forestry management, involving large investments in reforestation; and the development of adequate international requirements for the conservation of forests and their reproduction. The expected development of afforestation is shown in Table 35 [44]. A number of countries have made successful efforts in the field of reforestation. In China, for example, total forest area increased from 5 per cent in 1949 to 12.7 per cent in 1978. In the Byelorussian SSR reforestation has taken place in 204 thous. hectares [112] over the last 13 years.

Reforestation in the USSR is also carried out on a large scale. Taking into account the forest legislation and environment conservation programmes, over 1,000 million roubles are allotted annually for the development of forestry, including 160 million for reforestation. In 1976 to 1980, reforestation and conservation afforestation were organized in an area of about 12 million hectares, drainage of swamp stands up to 1.5. million hectares, and afforestation 230 million hectares.

Table 35

State and Expected Development of Forestry Programmes (FAO report)

Countries	Forest cultures area, thou. ha		Increase for 20 years (times)
	actual 1965	estimated for 1985	
Europe			
Belgium	296.0	355	1.2
Denmark	120.0	150.0	1.2
Finland	141.0	770.0	5.0
France	1100.0	2650.0	2.4
Greece	137.5	555.0	4.0
Hungary	514.0	994.0	1.9
Italy	833.0	1058.0	1.2
Luxemburg	24.0	27.0	1.1
Norway	170.0	490.0	2.9
Poland	758.0	1058.0	1.4
Spain	1600.0	2867.0	1.8
Sweden	140.0	500.0	3.6
Switzerland	38.0	45.0	1.2
United Kingdom	1266.0	1812.0	1.4
North and South America			
Argentina	240.0	500.6	2.1
Bolivia	23.7	122.3	5.2
Brazil	500.0	1144.0	2.3
Canada	295.0	916.0	3.1
Chile	354.3	3054.0	8.6
Cuba	143.0	143.0	—
Urugvay	154.5	377.5	2.4
USA	10353.0	26865.0	2.6
Africa			
Algeria	72.0	601.5	11.1
Angola	103.2	262.2	2.5
Egypt	15.2	30.2	2.0
Gabon	14.0	71.0	5.1
Ivory Coast	5.3	19.4	—
Kenya	89.0	160.0	1.8
Libya	56.0	169.5	3.0
Malawi	25.1	72.2	2.8
Morocco	175.9	620.0	3.5
South Africa	923.0	1074.0	1.2
Sudan	26.6	120.1	4.5
United Republic of Tanzania	18.6	113.0	6.0
Tunisia	80.1	465.0	5.8
Uganda	16.7	33.1	2.0
Asia			
India	954.0	2369.0	—
Indonesia	2181.0	1281.0	
Israel	35.7	74.3	2.1
Japan	7087.0	13300.0	1.9
Philippines	126.5	799.7	6.3
South Korea	1527.0	3704.0	2.3
Thailand	21.1	161.9	—
Turkey	46.7	227.2	4.9

Talbe 35 *(continued)*

Countries	Forest cultures area, thou. ha		Increase for 20 years (times)
	actual 1965	estimated for 1985	
Australia and Oceania			
Australia	294.8	953.0	3.2
Papua-New Guinea	5.5	40.5	7.4
New Zealand	462.1	781.0	1.7

In spite of these achievements, the state of affairs in the world forest resources reproduction is far from satisfactory. According to data compiled by the Royal Forest Institute of Sweden (1974), the entire forest area amount to 20 per cent of world dry land and occupies 2,657 million hectares. The USSR and Latin America share 25 per cent of this figure, North America 18 per cent, Asia 15 per cent, Africa 7 per cent and Europe 5 per cent. The territories where forests were destroyed amount to 12 per cent of the dry land, or 1578 million hectares. In continents and countries they are distributed as follows: Africa 43 per cent, Europe 23 per cent, Latin America 18 per cent, the USSR 15 per cent, North America 11 per cent. Forests are annually cut down in an area of about 11 million hectares [112].

In South-East Asia, South and Central America and Africa, the areas of humid tropical forests are being rapidly reduced. These forests occupy 935 million hectares, 35 per cent of the world forest area. According to FAO, their area annually reduced by 15 per cent as a result of an intensive increase of lumbering, cutting-and-burning farming, clearing the jungle for construction purposes, building highways, etc. But the main losses are inflicted by improper forestry management. In tropical countries, the system of selective felling is mainly intended for high-qua-

lity wood, which does not create favourable conditions for natural reforestation.

In Asia and Oceania, over 5 million hectares of forest are annually cut down as a result of forest exploitation and expansion of agricultural areas, more than 1 million deteriorate due to cattle grazing and control-free fellings. Most countries do not have scientifically based land-use programmes. Cutting-and-burning farming dominates in the forests (30 per cent of the area) of South-East Asia. In Thailand, the forest area decreased by 25.3 per cent within the period 1952 to 1978, while in the Philippines 2 million hectares of forest were destroyed by burning farming, which is also the technique in 23 million hectares of forest area in Indonesia. A similar situation holds in Afghanistan, Pakistan, the Republic of Korea and China. In order to diminish the negative impact of this technique, afforestation and forest conservation programmes are needed as well as speeding up forestry intensification.

Forest Pest and Disease Control

Considerable economic and material damage is inflicted on world forestry by various pests and forest plant diseases. A rough classification of hazardous and infectious diseases of wood species made by L. I. Vorontsov and N. Z. Kharitonova underlines the following negative consequences [113]: partial growth gain losses in stands due to insects biting-off conifer needles and causing foliage damage of trunks and roots, sucking-out tree tissue, etc.; felling of stands prior to attaining the necessary growth and optimum felling age; functional disorders in stands resulting in an undesirable development of some biological processes (substitution of fine wood species by low-value temporal species, deterioration of natural reforestation and wind resistance, development of diseases, etc.); delays in afforestation of cutting and burnt areas leading to undesirable charge in wood species; deterioration of stand quality which causes the reduction in forest capacity, premature ageing and decreases of biological resistance; decrease in commercial wood output, its partial devaluation and shortening the service life of wooden structures and facilities; deterioration of fruit bearing or entire loss of fruit and seed crops of wood brush and valuable nut family species; and decrease of the green stand service life in steppes, in sandy soils and along railways which causes cropping power decrease, the development of sand storms, etc.

Forest pests feature great variety and number. The following are the main groups: conifer needle and folliage pests, trunk and root pests, and fruit and seed pests. Conifer needle and foliage pests and the most widely distributed group (butterflies, sawflies, longicorn beetles, leaf beetles weevils, blister beetles, etc.).

Outbreaks of mass reproduction and distribution over hundreds of thousand of hectares cause tree shrinkage.

Chemical and biological plant protection together with sanitary and prophylactic measures are used for conifer needle and foliage pest control. The most successful method is the use of pesticides in the period of larva growth. Attraction of insectivorous birds to forests, protection and colonization of ants, parasitic fungi, bacteria, viruses and other agents have given good results among other biological methods of pest control.

Trunk pests are usually represented by beetles (bark beetles, long-horned beetles, weevils, etc.), hymenoptera (horntails) and butterflies (wood-fretters, clearwing moths, etc.) Prophylactic methods are mainly used against the latter group; therapeutic-chemical con-

trol methods are effective for root pest control. The control of fruit and seed pests in difficult.

Sterilization, microbiological and biological control methods, etc. show promise in the field of forest pests control.

Human Impact Upon Wild Fauna

The ecological habitat of fauna and flora are gradually changing under the influence of uncontrolled human activity. These changes have a negative effect on the specific and quantitative composition of animals and plants. Auroch and lion had become extinct prior to other species of modern animals in Europe. Almost the same happened to bison. The number of ibex and chamois was reduced sharply, and carnivores such as the bear and the wolf also suffered to a great extent.

Considerable changes have been registered in birds; the European ibis became extinct for unknown reasons, and such birds of prey as the griffon and the bearded vulture became very scarce. In North America, the carrier pigeon has become extinct [114].

Man is responsible for extermination of Carolina parrakeet, Eskimo curlew and great auk, the catastrophic decrease in the number of prairie grouse, whooping crane, California condor and some other species of the North American birds. Man is also guilty of almost entire extramination of such mammals as American bison, tundra reindeer, forest reindeer, pronghorned antelope and grizzily bear. J. Dorste believes that North America is one of the most evidences of the natural complex destruction by so-called 'civilized man' [35]. In South America, the endangered include: chinchilla, wild llamas (Lama guanichus) and fur seal (its related subspecies Guadalupe fur seal is available in a limited number). Steller's sea cow, sea mink and Labrador eider are other extinct American animals.

The mass movement for saving dying out animals commenced in the United States in the late nineteenth century. A certain progress was made due to governmental and private financing of natural resources reproduction programmes, adoption of various wildlife protection laws and the establishment of numerous public organizations, reservation and game refuges. Saved animals and birds included: beaver, American red deer and its relations, sea beaver, northern elephant seal, trumpeter swan, Carolina duck, wild turkey and egret.

At the same time, the ivory-billed woodpecker, polecat, baleen whales, southern right whale, northern right whale, blue whale, fin whale, walrus, Guadelupe fur seal, West Indian seal and Hawaiian monk seal, Florifa manatee, Mexican duck, Canada goose and tree-frog are gravely endangered. Zoologist R. McKling thinks that, in the future, the following animals may become victims in America: grey wolf and maned wolf, kit and swift fox, puma, grizzily bear, Alaska brown bear and polar bear. A similar situation is observed in other regions.

Such rodents as the agouti and the fafily of spiny rats, as well as Cuban parrots became extinct in the Carribean. The same misfortune struck many animals of the high endemic rank.

Flora and fauna of the Galapagos islands have undergone considerable changes. The number of giant land tortoises, water lizards — iguanas, cormorants, Galapagos penguins sharply decreased.

In the Asian continent, the following are endangered: Javan rhinoceros, Sumatran rhinoceros and great Indian rhinoceros. The Japanese creasted ibis, white crane, great Indian bustard, Indian lion, antelope, saiga, Prjewalski horse, Bactrian camel, Indian porcupi-

ne, some species of Chiroptera, Zaravshan pheasant, and white stork are reduced in number.

The 'troglodyte' birds, moas and most marsupials have become extinct in Australia and Oceania. The short-tailed albatros has been practically exterminated. In Africa, such animals as elephants, lions, African pied and roan [illegible] and [illegible] a long time ago. The African fauna is suffering great losses.

According to estimates made by IUCN (1978), about 1,000 species are endangered at present. In spite of this a number of countries still take anti-[illegible] tions of mountain gorilla remain in the area of the Varunga volcanoes (Uganda, Rwanda and Zaire) and Bwanti forest reservation (Uganda). They suffer from wood lumbering works and one has decreased to 250 specimens. The felling of evergreen forests exerts a negative influence upon the macaque population in South India as well. Young [illegible] led in hunting, are sold [115]. Crocodiles are on the verge of extinction; alligators, on the other hand, are not.

[illegible] ducts into sea water has done great harm to sea birds. Over 20,000 birds of [illegible] the result of the Amoco Cadiz accident [116].

In spite of international agreements [illegible] cat hides continues as well as pirate [illegible] of the countries which had not signed [illegible] the Convention, Japan still imports a [illegible] by the countries whose whale hunting [illegible] agreements [117].

Conservation of Fauna and Flora

In international practice, the protection of fauna and flora is carried out through the adoption of various agreements, treaties, declarations, conventions, projects and programmes as well as by the organization of international conferences, seminars and symposia and the creation of a global network of protected territories.

In 1979 in Bonn, the representatives of twenty-two countries signed the Convention on Protecting Migrating Wild Animals, by which was understood the [illegible] lower taxons of wild animals which occasionally cross state borders in great number.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora has been in operation since 1973. The second conference of this Convention was held in San Jose (Costa Rica) in 1979. The fur trade issue pertaining to some species was [illegible]ially emphasized at the Conference. The view that wildlife resources might be used until their extinction, followed by creation of alternatives was sharply criticised. The decision was made to extend the list of animals to be hunted only with special permission (all species of hawks, eagles and owls). The Conference permitted Papua-New Guinea to sell crocodile leather, taking into account the commercial breeding of cro-[illegible]

In 1979, the ECE Council of Ministres adopted the Convention of Wildlife Protection in Europe. Special attention was given to endangered species and species with variable geographic range. List I gives 119 plant species to be protected by separate states; list II enumerates the animals under strict [illegible] reptiles and [illegible] amphibians.

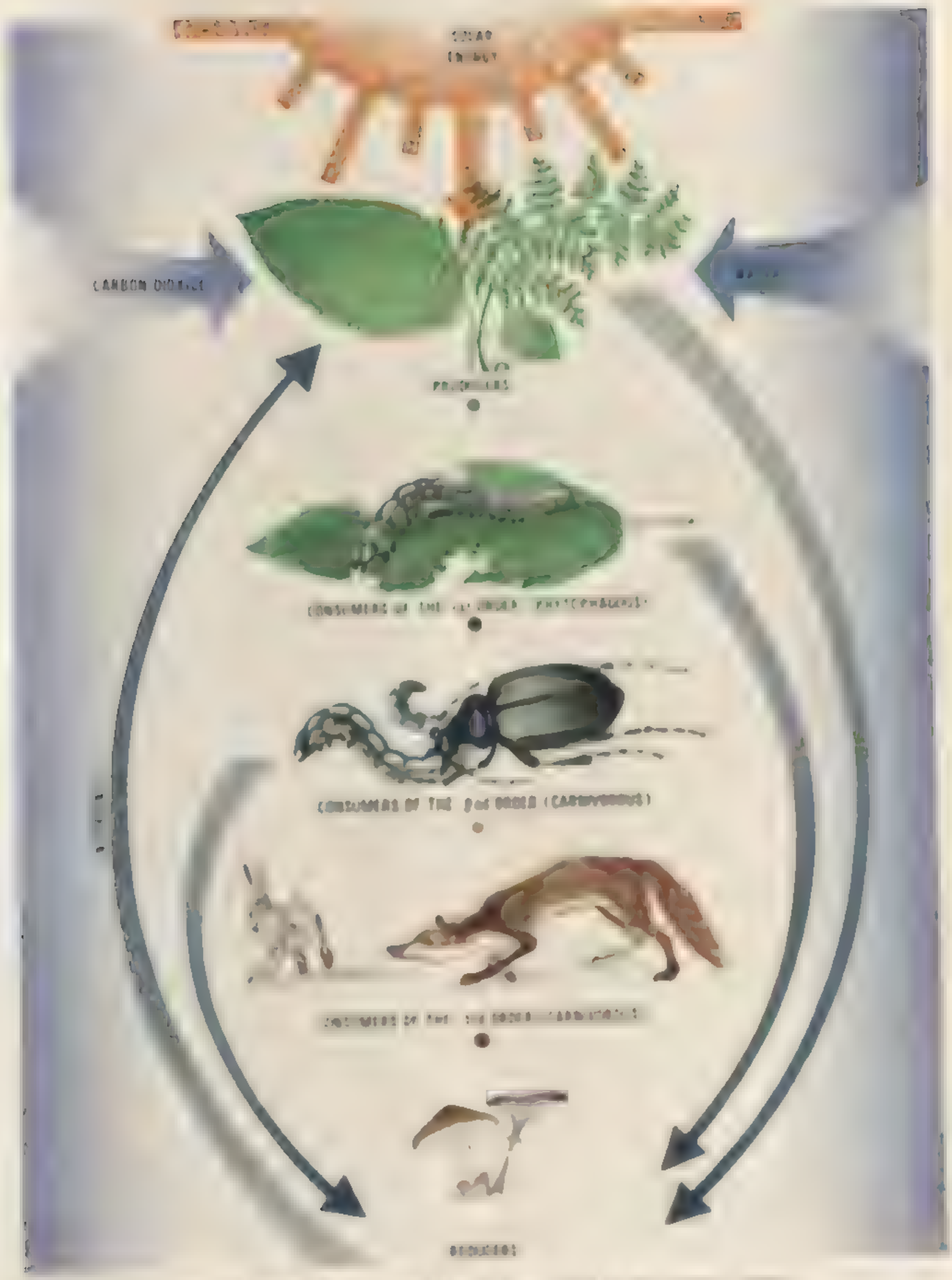

SOLAR ENERGY
CARBON DIOXIDE
WATER
PRODUCERS
CONSUMERS OF THE 1st ORDER (PHYTOPHAGOUS)
CONSUMERS OF THE 2nd ORDER (CARNIVOROUS)
CONSUMERS OF THE 3rd ORDER (CARNIVOROUS)
REDUCERS

Fig. 4 [illegible]

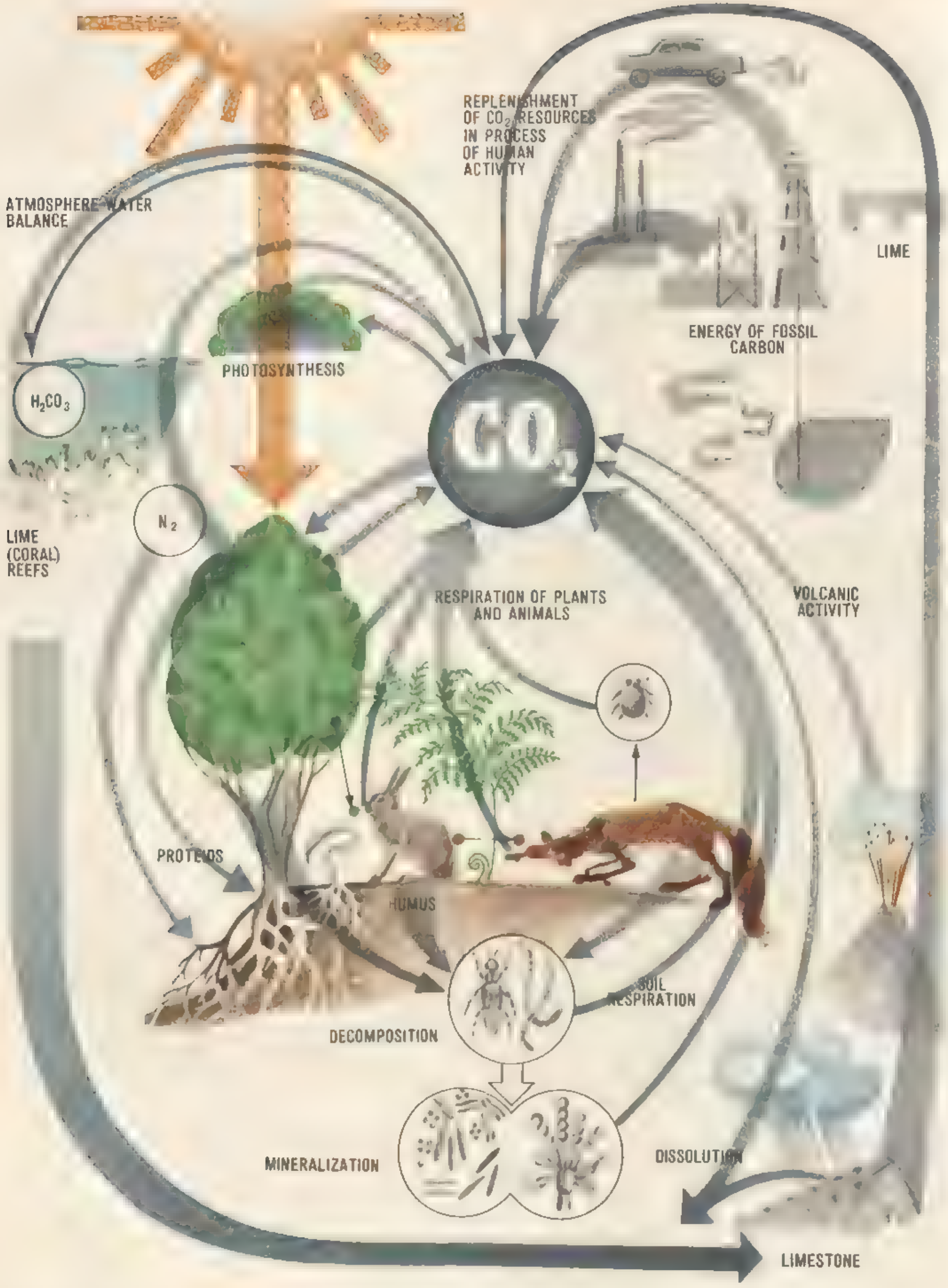


Fig. 5. Scheme of carbon cycle (according to Duvigneaud, Tanghe, 1967).

Black colour corresponds to mobile carbon available in organisms. in a gaseous state as carbonic acid, in a solid state as living and died off organic compounds Gray colour shows petrified (fossil) carbon: lime deposits, oil, coal, peat Petrification of carbon compounds is coloured faint black-gray

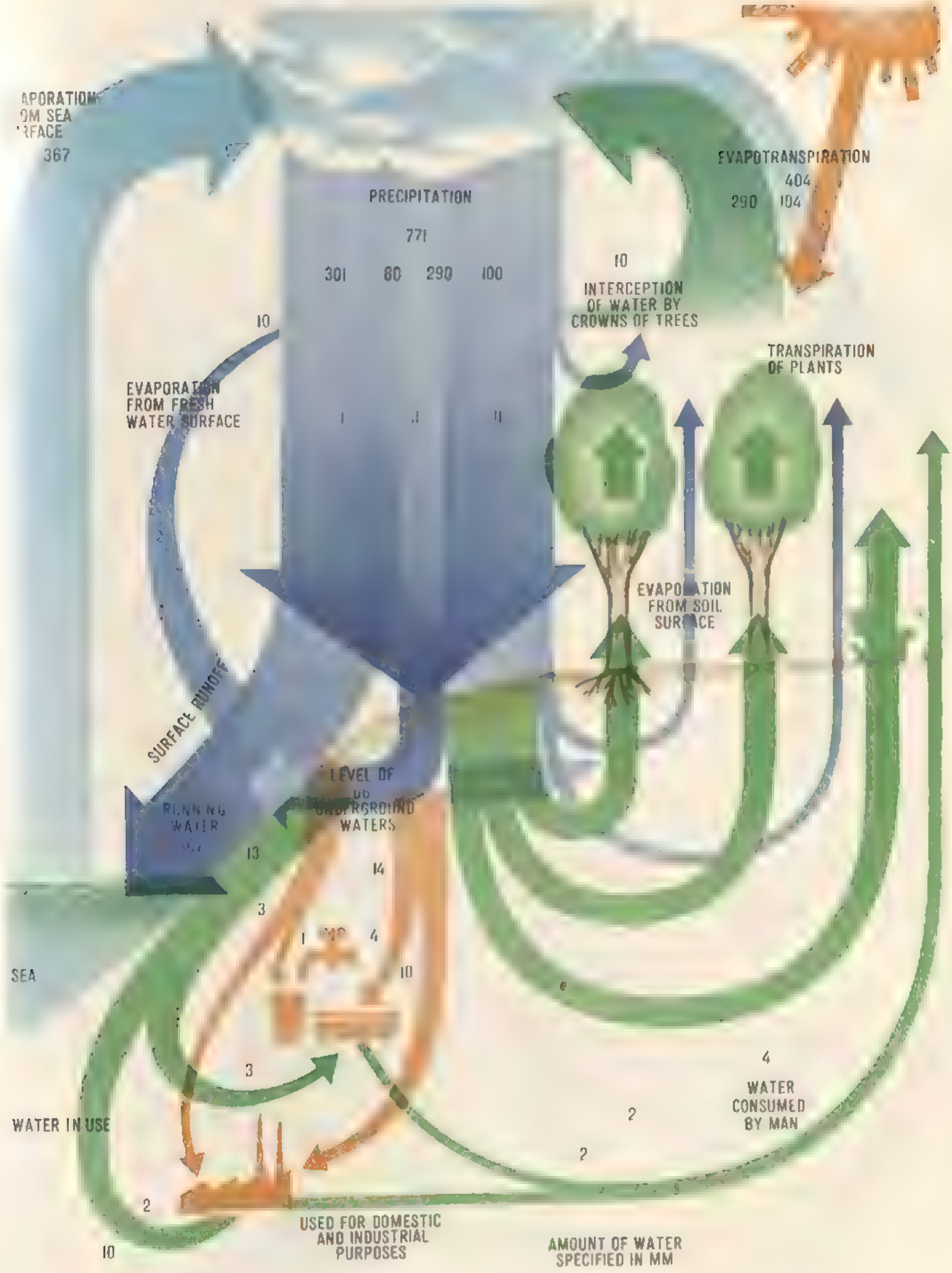


Fig. 8. Diagram of water cycle (according to Duvigneaud, Tanghe, 1967)
I — surface runoff; II — subsurface runoff; III — percolation

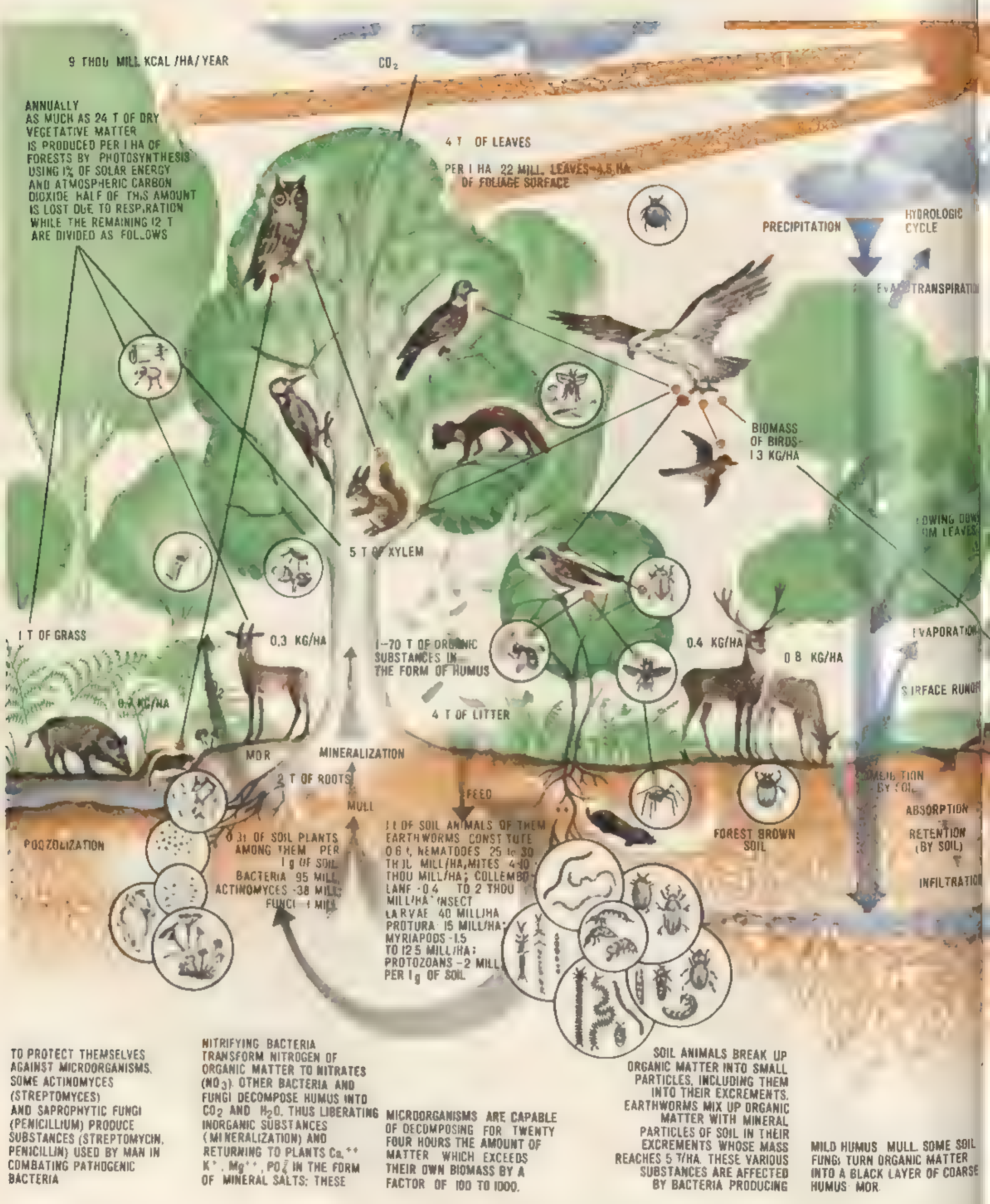
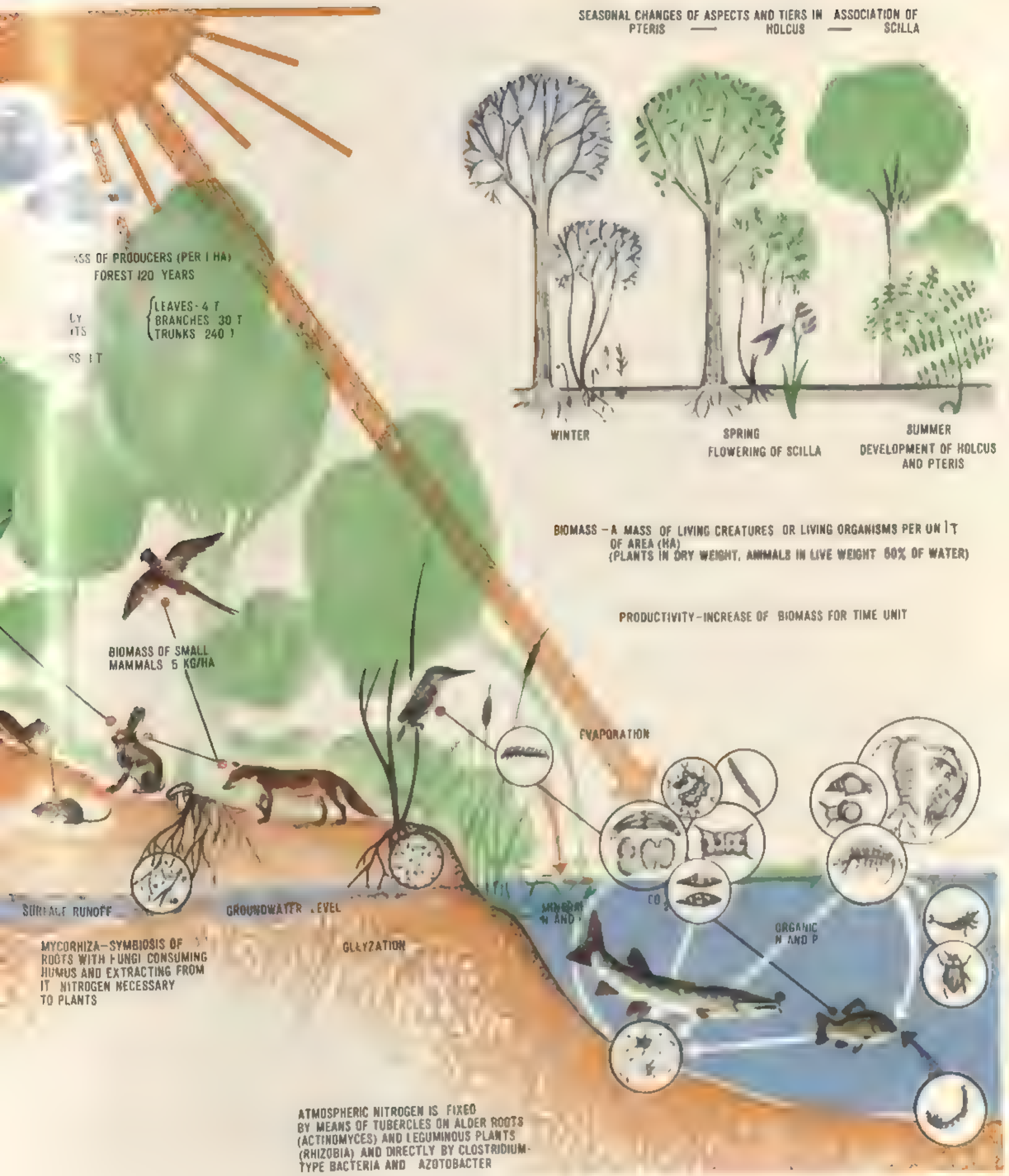


Fig. 13. Forest ecological system of Central Europe



(according to Duvigneaud, Tanghe, 1967)

Ussuri tiger

Leopard

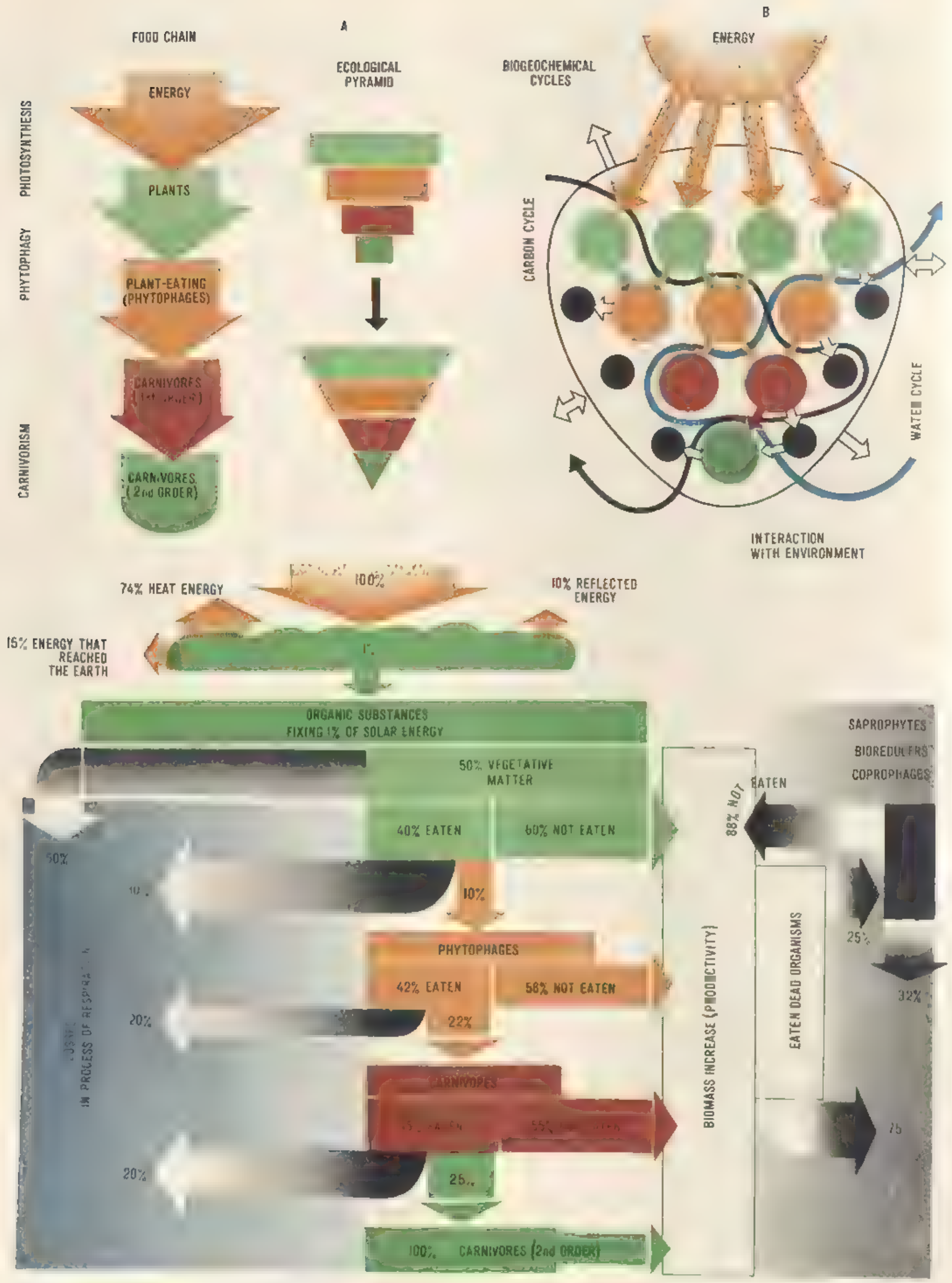


Fig. 14. Interrelations between the ecosystem components (according to Duvigneaud, Tanghe, 1967)

IUCN pays particular attention to the protection of plants and animals. It brings together 51 states, 106 governmental and 270 non-governmental organizations. Various international organizations such as the World Wildlife Fund (WWF), the International Council of Bird Preservation, the International Bureau of Fowl Study and others are part of IUCN. IUCN activities are variable and widely-ranged. Their **Red Data Books on Birds and Plants** were published in 1978—1979. In 1979, WWF financed 178 projects, 131 of which were related to land and 47 to the sea. In the same year, IUCN, WWF and UNEP jointly organized the Committee on a World Nature Conservation Strategy, which plans and develops the programme for fulfilment of the strategy.

At the national levels, fauna and flora conservation has been achieved through legislation, economic sanctions and the creation of a wide network of reservations and game refuges.

POPULATION PROBLEMS

Evolution of the Population

The dynamic population presented in Table 36 shows that the number of people inhabiting the Earth is growing. The growth rate, however, varies considerably [49].

In the early stages of mankind's development, the population growth rate was rather slow. This stemmed from a high death rate caused by famine, diseases, natural disasters, internecine wars, fighting wild beasts, religious rites and high infant mortality. In prehistoric times, the average life span was very short, 20 to 25 years. At the same time, the birth rate was higher than the death rate, thus ensuring a natural increase. Transitional to cattle breeding and farming, and the related division of labour, created a sound basis for decreasing mortality, which resulted in a rapid growth of population living under favourable climatic conditions. In other regions of the world, namely, in the tropics, deserts, taiga and tundra, the growth rate, like the size of the population, remained insignificant.

On the whole, in the period of barbarism, owing to primitive society relations and early class division, the population growth rate was relatively stable in some areas. At the beginning of the new era, the planet was inhabited by more than 200 million people; 50 million lived within the boundaries of the Roman Empire and 40 to 50 million in the regions of China and India.

Table 36

Dynamics of Population up to the 20th Century

Year	Whole world	Russia	Europe without Russia	Asia without Russia	Africa	America	Australia and Oceania
			Mill. people				
5000 B. C.	30	1	3	20	5	1	0.5
0	230	5	35	155	30	4	1.0
1000	305	10	43	195	40	15	1.5
1500	440	15	75	260	60	27	2.5
1650	550	20	82	330	100	15	3.0
1800	952	50	160	620	90	30	2.0
1850	1247	75	205	790	110	65	2.5
1900	1656	130	295	950	130	145	6.0
			In per cent of total population				
5000 B. C.	100	3.3	9.8	65.7	16.3	3.3	1.6
0	100	2.2	15.2	67.4	13.0	1.7	0.5
1000	100	3.3	14.1	64.0	13.1	5.0	0.5
1500	100	3.4	17.1	59.2	13.6	6.1	0.6
1650	100	3.6	14.9	60.0	18.2	2.7	0.6
1800	100	5.3	16.8	65.0	9.5	3.2	0.2
1850	100	6.0	16.5	63.3	8.8	5.2	0.2
1900	100	7.8	17.8	57.4	7.8	8.8	0.4

Table 37

Dynamics of Population in the 20th Century

Regions	Number of population, mill people					Increment, %		
	1950	1960	1965	1970	1975	1950—1960	1960—1970	1970—1975
Whole world	2,501	2,986	3,288	3,610	3,967	19.4	20.9	9.9
USSR	180	214	231	243	255	18.9	13.6	4.9
Europe (not including USSR)	392	425	445	459	473	8.4	8.0	3.1
Eastern	89	97	100	103	106	9.0	6.2	2.9
Southern	109	118	123	128	132	8.7	8.5	3.1
Western	122	135	143	148	153	9.8	9.6	3,4
Northern	72	76	79	80	82	5.6	5.3	2.5
Asia (not including USSR)	1,368	1,644	1,824	2,077	2,256	20.2	23.2	11.3
Eastern	675	788	854	926	1,005	16.7	17.5	8.5
South-Eastern	173	217	248	283	326	25.4	30.4	15.2
Southern	475	581	656	742	837	22.3	27.7	12.8
South-Western	44	58	67	77	88	31.8	32.8	14.3
Africa	219	273	309	352	401	24.7	28.9	13.9
North	52	66	72	86	98	26.9	30.3	14,0
East	62	77	88	100	114	24.2	29.9	14.0
West	65	80	90	102	115	23.1	27.5	12.7
Central	26	32	36	40	45	23.1	25.0	12.5
South	14	18	21	24	28	28.6	33.3	16.7
America	330	414	461	509	561	25.4	22.9	10.2
North	166	199	214	226	237	19.9	13.6	4.5
Central (Including Mexico and Islands)	53	69	79	92	105	30.2	33.3	14.1
South	111	147	167	191	218	32.4	29.8	14.1
Australia and Oceania	12	16	18	19	21	33.3	18.8	10.5

The early Middle Ages brought no serious changes in the population growth rate, but the second half of the second millenium is featured by a slight gain, mostly due to China. Nevertheless, outbreaks of epidemics and numerous internecine wars and wars of conquest lasting for several decades had their negative influence. The situation underwent gradual changes in the 18th and particularly the 19th centuries, when for a 100-year period alone (1800—1900) there was an increase of population which in the past would have taken eighteen centuries (722 million).

Main Causes of Population Growth

Changes in population depend on reproduction and the socio-economic and cultural conditions of development of a particular country and people, taking into account historically established conditions of labour renewal. The causes of population growth, especially in Africa, Asia and Latin America, are as follows: successful control of epidemic diseases; effect of the 'green revolution'; fewer local famines; social inequality; regional motives; poverty; illiteracy; social dependence on offspring; sharp reduction in death rate; improved sanitary-hygienic conditions; young age structure of population; stability of social structure of rural populations; and length of average life span.

At the same time, the population in the countries of North America and Europe was greatly influenced by modern processes of scientific and technological revolution, namely, the high level of economic development, increased ave-

Table 38

Prediction of Population in Main World Regions According to «Average» Variant (mill. people)

Main regions	1970 (actual)	1980 *	1990 *	2000 *
Whole world	3610	4374	5280	6254
Developed regions	1084	1181	1277	1360
Developing regions	2526	3193	4003	4894
USSR	243	268	294	315
Europe (not including USSR)	459	487	514	540
Eastern	103	110	116	121
Northern	80	84	87	91
Southern	128	137	147	156
Western	148	156	164	171
Asia (not including USSR)	—	—	—	—
Eastern	927	1088	1233	1370
China	772	908	1031	1148
Japan	104	118	126	133
Other countries	51	63	76	89
Southern	1101	1427	1836	2267
Eastern	283	371	479	592
Central	742	954	1222	1501
Western	77	102	136	174
Africa	352	462	614	814
East	100	132	178	240
Central	40	51	67	88
North	86	113	150	192
South	24	32	43	56
West	102	132	177	238
America				
North	226	249	275	296
Latin	283	372	486	620
Caribbean area	25	30	37	45
Central	67	93	128	173
Moderate climate zone of South America	36	42	47	52
Tropical South America	155	207	273	351
Australia and Oceania	19	23	28	33
Australia and New Zealand	15	18	22	25
Melanesia	3	4	5	6
Micronesia and Polynesia	1	2	2	2

* Estimated

rage life span, emancipation of women, increased marriage age, improvement of living standards, aspiration for culture and more intellectual human qualities, etc.

Demographic Situation and Prospects for the Future

In 1975, the population of the world totalled 3,967 million people (see Table 37) [49].

Asia (excluding the USSR) accounts for 56.87 per cent of the world population, America — 14.14 per cent, Europe (excluding the USSR) — 11.92 per cent, Africa — 10.11 per cent, the USSR — 6.43 per cent, Australia and Oceania — 0.53 per cent.

1970 to 1975, the highest cumulative population growth rate, 13.9 per cent, was in Africa, owing to the reduced death rate in West, East and Central Africa accompanied by a very high birth rate. Specialists predict that this tendency will prevail in the near future.

Asia (excluding the USSR) holds second place as to the population increase rate, 11.3 per cent for the same period. On the whole, this region is characterized by a reduction in child mortality and mortality caused by epidemic diseases. In East Asia, and in China in particular, the early 1960s saw an annual population increase of 2.5 per cent, or 15 million people. As a result of the campaign launched in the 1970s and aimed at decreasing the birth rate, the natural increase dropped by 1.5 per cent, thus reducing the growth rate in China as well as for the region as a whole. For a long time, the population of Australia and Oceania depended on emigration and, later, on reduced mortality in combination with increased birth rate, which brought about a growth in natural increment among the indigenious population, particularly in Oceania.

The lowest population growth rate was established in the USSR and Western Europe. In the USSR, there was a drop in the natural population increase to 8.5 persons per 1,000 residents in 1977 compared with 17.8 persons in 1960, mainly resulting from a stable

death rate and reduced birth rate among Russians, Ukrainians, Byelorussians and in Baltic Republics [119].

According to L. Levi and L. Anderson, the percentage of total world birth rate in the following areas is: Southern Asia — 38, Eastern Asia — 22.8, Africa — 13.2, Latin America — 8.7, Europe — 7.1, the USSR — 3.9, North America — 3.6, Japan — 1.6, moderate zone of Latin America — 0.9, Australia and New Zealand — 0.3.

As to age structure, the most numerous group is that comprising children under 15, which in developing countries alone accounts for 42 per cent of total population. The life span in the industrialized countries averages 71 years, in Latin America — about 60, in Asia — 57, and in Africa — 47 years [120].

One of prediction variants of prospects for population number is shown in Table 38.

HYGIENE, HEALTH AND NUTRITION PROBLEMS

Pollution and Public Health

In 1972, a WHO committee of experts thoroughly investigated the effect of polluted atmospheric air on the health of the population and, in a corresponding review, presented information concerning a number of specific substances, including sulphur oxides and particulates, carbon oxides, photochemical oxidants and nitrogen dioxide. A given content of sulphur oxides and particulates may create certain unfavourable consequences for human health, taking into account their simultaneous presence in the atmosphere.

When considering the effect of carbon monoxide, its concentration is very important, as well as the time of its action. Saturation of the blood with carbon monoxide up to equilibrium saturation proceeds relatively slowly: about three hours are necessary or reach 50 per cent saturation under relatively low initial level of carboxyhemoglobin (about 0.5 per cent) under weak physical exercises.

Smokers, as well as people exposed to carbon monoxide from other sources, develop a high carboxyhemoglobin content in blood, thus reaching an equilibrium saturation state in a shorter time; if the carboxyhemoglobin content in blood exceeds equilibrium level, then excretion of carbon monoxide occurs even before reaching the equilibrium state. Prophylactic measures should be directed to prevent carboxyhemoglobin accumulation in blood in quantities up to 4 per cent and higher, because data available show that reaching this level involves changes in the state of organism as well as a greater risk for persons suffering from cardiovascular diseases.

Photochemical pollution of the atmospheric air tends to be within limits of separate areas and occurs only when there is intense solar radiation serving as an energy source for photochemical reactions.

According to EPA, as the result of atmospheric pollution in 1975 to 1980, the United States could suffer 25 thousand premature deaths, the loss of 160 million man-days due to an increase in lung and heart diseases, about 50 million additional attacks of asthma, 2 to 5 million acute respiratory diseases, etc.

In the opinion of Chief of the United States Medical Board, in the 1980s the nation will face a number of grave ecological problems resulting from the production of toxic chemicals with seriously worsen, in ways not yet fully

understood, the burden of diseases haunting man. The hazard to the health of the nation will continue until the paths of penetration of these harmful compounds into the environment are successfully detected and monitored [121].

The United States annually produces more than 35,000 million kilograms of hazardous chemical waste and out of which one tenth remains harmless. The bulk of the waste penetrates through the soil and rocks, spoiling underground waters which are the source of potable water for half of the country's population. A private research organization showed that sixty-six companied daily discharge almost 10 million gallons of polluted sewage into eleven municipal sewer systems on Long Island. But since none of these systems is equipped for treating toxic waste, the potable water used by about 3 million New York residents is under threat [121].

The water sources in twenty-two Massachussets towns are polluted with chemical substances. In Michigan, inspectors identified 300 places of polluted ground waters. The residents living near Maxingen now drink water delivered only from other areas in containers, since their local water looks more like a dark foamy beer [121]. The extent of such poisoning, according to E. Magnuson, P. Stoler and M. Nash, will grow as the chemical substances which have long been forgotten, will begin to penetrate the new underground reservoirs from which Americans take drinking water. In their opinion, because of high development rate of the chemical industry and long period of decay of chemical substances, a man can no longer hope that his organism will develop genetic resistance against chemical pollutants, if that is ever possible [121].

The only viable solution of this problem rests upon more complete utilization of wastes and truly revolutionary change of the present technologies, the change based on waste-free and closed systems of industrial production. The principle that 'the one who pollutes is the one who pays' cannot provide the answer to this issue. According to EPA, the United States needs at least $ 50 billion to meet its environmental protection needs. Companies prefer to pay fines and discharge waste illegally rather than to invest in an enterprise promising no immediate profit. They do not care for health and lives of millions of people. From the total sum of accrued expenses for environmental protection, which in 1973 to 1982 (according to CEQ may reach $ 194.8 billion, the direct consumers will cover $ 77 billion, while the electrical companies and government taxes cover only 32 billion each [122].

It would seem logical that, under such conditions, the government should increase its spendings for public health and medical care; but quite the contrary, hospital bills are sky-rocketing. Nothing is said about any compensation to persons suffering from environmental pollution by industrial waste, because, first, in most cases the names of those responsible remain unknown and second, money cannot repair damaged health.

When investigating the extent of pollution in developing countries, O. K. Dreyer and V. A. Los emphasize the following aspects: first, although some areas and cities in Asia, Africa and Latin America are severely polluted, the average level of pollution in developing countries is not one of ecological crisis; however, if the drastic measures are not taken, the situation may get worse. Second, the developing countries are at different stages of pollution, because they differ as to their extent of industrial activity and historical and territorial conditions. At present, the least polluted is the African continent and most polluted are the countries of Asia and Latin America.

Increased environmental pollution reduces the quality of life and spreads diseases. For instance, miscalculations in construction of dams or other irrigation facilities creates conditions for spreading of schistosomiasis, a disease which in some developing countries occurs more frequently than malaria. As far as malaria is concerned, despite strenuous and long-lasting efforts, it still holds at risk hundreds of millions of people in developing countries, mostly because of lack of water of required quality and absence of satisfactory waste processing facilities. In many regions of Africa, the problem of malaria has reached such proportions that all existing methods of combating carriers appear to be ineffective [123].

Thus it becomes obvious that in developing countries the main causes of pollution and increase in diseases, including the infectious ones, are not industrialization and technical progress, but famine, malnutrition and unsatisfactory sanitary and hygienic conditions.

Additional Information

An essential to improving of health is a general attack upon unjust social systems, incorrect allocation of investments, careless application of technological achievements and a thoughtless behaviour of people.

Both in industrialized and developing countries, the improvement of health demands both changes in state policy and in individual habits. But, depending on the medico-sanitary conditions existing in societies, a different order of priority should be established for these changes. Social reorganizations which would provide the population with full nourishment, a water supply and sewer systems are vital in countries with low per capita income. In developed countries, health improvement requires changing individual habits. Until people give up smoking, high-caloric diets and a sedentary life, the most strict atmosphere pollution and toxic substances control and qualified medical care will be unable to radically change the existing situation. If well thought-out planning helps developing countries to avoid the dangers arising from industrialization and luxury, and the existing traditional dangers are simultaneously removed, this will create conditions for people which cannot be provided by money alone.

Comparison of world mortality indices points to the immediate task of mankind — to reduce sharply infant mortality due to undernourishment and infections (annually, they cause the death of about 13 million children under 5 years of age).

Public health facilities in developing countries, where deaths are still caused by factors which can be prevented by modern medicine, are often unable to provide elementary aid to poor populations, particularly in villages.

Diseases caused by poverty can be eliminated by eliminating its social and physical sources. Health improvement for the poorest half of the world's population requires land reform, credit to small farms, family planning, doctors and drugs. A health strategy which included medical attendance as a component should take into account cultural and economic factors influencing nutrition and sanitary-hygienic conditions.

Two prerequisites for a satisfactory state of public health are full nutrition and sufficiently hygienic conditions. When these are met, mortality inevitably decreases.

Programmes of food assistance to individual countries facing basic difficulties cannot solve the large-scale problem of malnutrition. Economic development favouring an increase in food output, employment prospects and a rise in the income of poor rural and urban

populations are factors which can eliminate malnutrition, while development involving economic inequality will only aggravate the existing situation.

The level of infectious disease on a global scale will decrease by 80 per cent if each individual uses pure water in sufficient amounts for sanitary and other purposes. Though providing normal sanitary conditions is the cheapest and easiest way for improving public health, for the time being only about one third of mankind reaps the fruits of the sanitary revolution which enveloped Europe and America at the end of the 19th century.

Local sanitation can be improved to a certain extent by mobilizing resources; however, the construction of water pipes and sewer (or water treatment) systems also requires money and a certain knowledge.

In 1976, WHO outlined what is considered a realistic global sanitary reorganization. By 1980, WHO hoped that states would allocate $ 35,000 million for five years, which would increase the percentage of developing countries populations using pure water and a sewer system from 29 to 38 per cent and from 25 to 32 per cent respectively.

If the goal were achieved, the sums would total less than 2.5 per cent of the world's military expenses for the same period. Another comparison may be adduced: funds necessary for the construction of water pipe line and sewer would have amounted to one twelfth of the sum spent by smokers for cigarettes. Nevertheless, with such modestly outlined goals, population growth will cancel out certain insignificant achievements, and the absolute number of people in need of elementary sanitary conditions will barely decrease.

Both in developed and developing countries, further significant achievements in the field of public health will depend on social changes rather than on medical science. In most industrialized countries, the conditions for preserving health are now, of course, better than ever. Though a potential life span for those who have survived childhood did not increase, a lot of people live for longer periods of time than before.

Though the environment in various countries has a different effect on human health, studies of local conditions and general tendencies lead to a conclusion that the growth of national economy and preservation of health cannot be considered as synonyms.

At present, all countries with a low per capita income do not follow the way of Europe and North America development in the nineteenth and in the early twentieth centuries. Economic and demographic situations in less developed countries have no historical parallels. These countries do not conquer new areas; moreover, many of them were subjected to colonization. Modern tendencies show that certain types of development intensify economic inequality, maintaining a large number of people in extreme poverty. Economic development unaccompanied by social reform may not only pass by a certain part of population; it may even trample upon it.

Care of human health suggests sanitation of the environment animate and inanimate. But it also requires man's careful attention to his fellow man, because forces engendering poverty remain the principal threat to human health [66].

Food and Nutrition Problems

United Nations specialists think that a sign of famine more disastrous than that caused by the drought of 1973/74 is haunting 150 million Africans. Hunger and malnutrition are constantly threatening the entire African continent. According to the United States World Food Council, twenty-six African countries faced serious food shortages

in 1980. Famine poses a real threat to more than 20 million people, 12 million of whom are threatened with malnutrition and more than 1 million people will starve to death [124]. Such countries as Cape Verde Islands, Chad, Gambia, Mali, Mauritania, Niger and Upper Volta, are in constant need of urgent food supplies. Kenya, Zambia and Zimbabwe, former food exporters, now have to cover their deficiency by food import. Botswana, Mozambique, Rwanda, and Zaire are experiencing food shortages.

Nowhere is the famine problem more catastrophic than in Karamoja, a Uganda cattle-breeding area with a population of over 350 thousand, where, because of droughts and cattle murrain, more than half the population is threatened with starvation. Aid, sent in accordance with the United Nations sponsored Development Program, because of frequent armed ambushes of the transports with food, seldom reaches Karamoja.

However, many experts emphasize that even if the droughts and other troubles are successfully handled, the starving and homeless people will depend on emergency aid at least until the end of the current decade. The only viable solution in the long-term perspective is realizable programmes for improving agricultural research in the whole African region, for crop rotation and the utilization of wells and for the construction of up-to-date roads which allow, in case of need, timely delivery of food to regions in need [124].

URBANIZATION AND ENVIRONMENT

Development of Cities and Environmental Conservation

The growth of cities, centres of socio-economic and cultural development, is one of the factors which determined world population growth. In turn, the concentration of population in cities is directly connected with the extension of industrial, agrarian, trade, transport and commodity-monetary relations and generally characterizes the objective processes of urbanization.

Urbanization influences the life of urban and rural populations and in many aspects reflects the level of the productive forces. By 1850 only 4 cities had a population of 1 million or more. 100 years later the number of such cities increased to 19 and by 1960 to 141. Some forecasts say that by the year 2000 the number will be 275. The biggest cities of the world are New York — 16,037 thousand people (United States, 1970, agglomeration), Tokyo — Yokohama — 14,525 thousand (Japan, 1970, agglomeration), London — 11,544 thousand people (United Kingdom, 1970, agglomeration), Mexiko City — 11,340 thousand people (Mexico, 1975, agglomeration), Shanghai — 10,820 thousand people (China, 1970, agglomeration), Paris — 9,863 thousand people (France, 1975, agglomeration), Buenos Aires — 8,925 thousand people (Argentina, 1974, agglomeration), Moscow — 7,819 thousand people (USSR, 1977), Peking — 7,570 thousand people (China, 1970, agglomeration), and Rio de Janeiro — 7,213 thousand people (Brazil, 1970, agglomeration). Urban population growth in basic world regions is presented in Table 39 [119].

Within a sixty-year period (1920 to 1980), considerable change has taken place in the share of separate regions in terms of the total urban population.

In the USSR, the urban population number increased by 147 million people and amounted to 9.6 per cent of the

Table 39

Dynamic of Urban Population in Main World Regions in 1920—2000 *

Regions	1920		1940		1950		1970		1980		2000	
	mill. people	%	mill. people	%	mill. people	%	mill. people	%	mill. people	%	mill. people	%
The whole world	360	19	570	25	692	28	1315	36	1791	41	3205	50
USSR	25	15	60	32	71	39	137	57	172	64	245	76
Europe (not including USSR)	150	46	200	53	204	52	284	62	326	67	414	77
Eastern Asia	50	9	85	13	99	15	246	26	363	33	645	47
Southern Asia	40	9	75	12	108	15	231	21	365	25	834	35
Africa	10	7	20	11	28	13	75	21	122	26	315	38
North America (USA and Canada)	60	52	85	59	106	64	168	74	196	79	256	86
Latin America	20	22	40	31	67	41	161	57	238	64	470	75
Australia and Oceania	5	47	5	53	8	70	14	70	17	72	26	77

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* Estimate — for 1920-1970, forecast — for 1980—2000. The number and share of urban population was made by the Commission on Population of the UN Economic and Social Council on the basis of national criteria adopted in separate countries for the urban population calculation.

world total. As a result of economic and cultural development, more than 1,000 new cities have been built in this country, while the old ones have completely changed their appearance. The objective population migration process and creation of entirely new spatial-structural forms and systems of settlement are closely connected with the policy of permanent development of heavy industry and agriculture — basic prerequisites for the growth of economic potential and improvement of living standards. From 1918 to 1979, capital investments in the Soviet national economy amounted to 1,964 thousand million roubles, the total value of the basic operated resources being 1,811.5 thousand million roubles. In 1976 to 1980, the capital investments in agriculture amounted to 170 thousand million roubles. The agricultural industry obtained in addition 1.8 million tractors, 1.3 million trucks, 540 thousand harvesters, considerable equipment for cattle breeding and fodder production and 400 million tons of mineral fertilizers. In spite of huge losses suffered by the country in the second World War, the national wealth value (excluding the cost of land and forests) constituted over 2.5 trillion roubles in 1979 and as compared with 1913, power resources and fuel output became 32.8 and 38.4 times as high, respectively. Within the period 1918 to 1979, some 3,403 million square metres of usable floor area were built, while housing facilities amounted to 2,134 million square metres of the usable area, or 8.13 square metres per capita. The number of gas-supplied apartments increased by 42.9 million in 1965 to 1979 (urban 25.5 million, rural 17.4 million) [125].

In order to prevent disproportions and achieve planned control over population settlement, the Soviet policy aims at restraining the growth of cities. Accommodation of new industrial enterprises (excluding public service objects) has been stopped to achieve this goal. Building of satellite towns is another line in solving the complex urbanization problems, the sole purpose of which is to reorganize the cities into smaller units and prevent them from excessive number of enterprises and residents.

Following are the main aspects of

town planning and building programmes in the USSR in order to estimate ecological phenomena in the urban development: architectural planning, which means taking measures for improving the populated areas environment including the creation of parks and gardens; technological aspect which makes provision for the implementation of waste-free and water-free processes as well as introduction of circulating and recycling water supply systems; and engineering aspect intended for centralized collection, storage, removal and neutralization of industrial and domestic waste.

In Moscow recently 330 water protective and 1,000 dust-gas purification works as well as 48 circulating and recycling water-use systems have been reconstructed. Over 500 enterprises have been modified or removed to beyond city limits, the number of dust and gas removal systems has been increased by 50 per cent. These measures made it possible to reduce both amount of harmful emission into the atmosphere by over 1,000 tons per day and discharge of industrial waste into water by 10 million cubic metres per year.

In prospective and annual plans for the development of some large cities, a special section provides for environmental conservation. A unique hydrotechnological complex on conservation and improvement of aquatic environment will become operational in Leningrad by the end of 1990. Sixty inspection stations and a regional state commission exercise monitoring of industrial purification works function in the city to check atmospheric conditions. Over 750 air purification works were built and modified in Leningrad between 1976 and 1978; 175 small boiler houses and other sources of pollution were eliminated.

Considerable efforts are being made to decrease the pollution of the Baltic Sea. Three purification complexes are being completed which will deal with 4 million cubic metres of water per day. Purification works in the suburbs of Leningrad will result in a highly efficient circular purification system. All problems of city development are not yet solved in the USSR.

During recent decades, the rapid growth of urban population in the developing countries of Asia, Africa and Latin America has outstripped the development of manufacturing industry, construction and infrastructure. An intense peasant dispossession of land, agrarian overpopulation and unemployment make people move to cities in search of a job and better living conditions, but their quantity is in excess of the cities' absorption capacities. As a result, one sees an enlarging of temporary block areas and overpopulated slums in city suburbs. Over 50 per cent of big cities' population in Africa, about 40 per cent in Latin America and 25 per cent in Asia live in such blocks and slums.

The spontaneous development of urbanization processes and the formation of the excessively large agglomeration systems lead to environmental degradation and cause the following harmful consequences: deterioration of human physical environment; reduction of land resources and green plantation area per city resident; deterioration of air and water quality; increase in the number of nervous and cardiovascular diseases; low birth rate; destruction of natural landscapes; increase in noise levels; excessive density of population and crowdness; worsening of sanitary and hygienic conditions; and decrease in real income of population due to unemployment growth and other factors.

In most developing countries of Asia, Africa, Latin America and the Pacific islands (involve about 1,200 million people), the available water sup-

ply systems do not meet present-day requirements, taking into account the intensive growth of urban population. In these countries, only 65 per cent of urban population use water pipe systems and only 3 per cent use the sewer system connected with purification works. This has a particularly detrimental effect in densely populated areas.

The environment quality factors and irreversible processes of urbanization are therefore closely interrelated and interdependent. Changes in one will affect the others. Probably the existing state of affairs can be changed only by taking into account not one or two but each and every basic component of the entire ecosystem. This must be done not in abstraction but based on an accurate assessment of conditions specific to each region, not only natural barriers to growth but also artifically created barriers of institutional, political and international origin. Unequal distribution of income and power in the world is one of the relevant examples.

Undoubtedly, we are dealing here with an equation of many unknown quantities. The rather obscure situation is complicated by the effect of considerable time lag. The precise quantities of available power and plowable land resources are unknown. No data are available as to the probability of emergence of new pure water sources and technological achievements likely to occur. Possible disorders in ecosystems and how they can possibly affect the behaviour of individuals and groups cannot be protected. Despite the fact that we cannot identify and quantitatively assess the effect and prospects for each factor, as well as the pattern of complex interaction, we must not deceive ourselves by denying the problem itself.

It is highly probable that the solution of these problems will not be found on the basis of a simplification strategy. Their solution is feasible only through combining interrelated strategic measures. The existing state of affairs is unique in the history of mankind and its improvement may require not only technological but even, and chiefly, social innovations, that is to say, through the determination of new public goals and means for their achievement [120].

Environmental Conservation and Development of Tourism

The acceleration of the scientific and technical process places additional ecologic loads on man's physical environment and also exerts an ever-increasing effect upon his physiology. On the one hand, it takes the form of nervous system overstress, an acceleration of life tempo and increase in the frequency of stress situations. On the other hand, considerable social changes coupled with the leisure time increase in some countries has resulted in new and rather steady requirements, including various kinds of tourism and recreation.

The number of recreationists and tourists permanently rises. For example, the Bureau of Outdoor Recreation estimates that in the United States recreation requirements will increase by 400 per cent within the period of 1960-2000. Some 15 million people annually stay in the Italian forests. Recreational intensity in Czech Karst (Czechoslovakia) amounts on the average to 1.2 to 1.7 people/hectare, while the number of week-end visitors is between 28 and 34 thousand. In the United Kingdom, about 14 million people go to the country on Sunday in the summer.

On the whole, 750 to 800 million people are engaged in various forms of tourism; the number of tourists in developed countries amounts to 60 per cent of their population.

International tourism develops rather intensively. The executive director of UNEP noted in his annual report

that the number of foreign trips made by citizens of various countries for tourist purposes within a ten-year period increased by 75 per cent and reached the figure of 243 million in 1977. International tourism is expected to grow annually on the average by 4 per cent [126].

International tourism accounts for 6 to 9 per cent of the total tourism income in the United States. It is found to amount to 17 to 18 per cent in Sweden, 24 to 26 per cent in the Federal Republic of Germany, 31 to 44 per cent in the United Kingdom, France, Norway, Canada and the Netherlands, 52 to 54 per cent in Poland, 59 to 60 per cent in Yugoslavia, 61 to 64 per cent in Switzerland, 72 to 75 per cent in Belgium, 83 to 85 per cent in Australia, and up to 90 per cent in Ireland. In Kenya, the annual income from tourism in the national parks area reaches $ 100 million [127].

Due to the intensive development of the tourism industry, its impact upon the environment has considerably increased. First, the element of world economy has been strengthened because the problem of meeting the recreational requirements related to health protection and rehabilitation means a quantitative increase in the conserved areas, picturesque terrains and reservation zones, working out plants of recreational areas development, ecologically sound location of industrial enterprises within recreation zones, etc.

For example, in the Netherlands, five kinds of land are allotted for recreational purposes only and twenty national parks with a minimum area of 1 thousand hectares are planned. Farming in these areas is prohibited. Approximately 10 per cent of all resources allocated for land reclamation are intended for recreational purposes.

In Bulgaria, several categories of conservation areas have been established, including reservations, national parks, conserved areas, natural sites of interest, historical monuments, etc. In 1940, the country had little more than fifty conserved objects, while by 1979 this had grown to over 2,500 thousand with a total area over 107 thousand hectares, including 82 reservations, 8 national parks, 331 natural sites of interest, 43 conserved areas, and 747 historical monuments. Twenty-five Bulgarian reservations are included in the United Nations list prepared by the International Commission on National Parks and the International Union for the Conservation of Nature and Natural Resources.

The plan for conserving the Siberut island (Indonesia), which features unique flora and fauna, envisages its transfer into the biospheric reservation category, with the establishment of limited land use and tourists route zones.

The conservation of landscape and aesthetic qualities of the Carpathians (USSR) presupposes the development of architectural and terrain division of the mountain areas, taking into account local conditions and their effect upon the formation of perspective settlement systems, infrastructure, architectural and spatial arrangement of populated areas, landscape and aesthetic estimation of the territory, its architectural, historical and ethnographic significance as well as the effect of urbanization processes on the natural environment.

There is a system of sixteen regional parks on the New South Wales coast of Australia. These include four parks on the ocean coast, eight around inland water bodies and four in the river valleys. Their development and planning programmes envisages increasing the efficient use of natural resources on the basis of determining the necessary recreational potential, and the most intensively exploited and badly kept zones as well as a complex control system of recreational facilities.

In Hungary, since 1957, the recrea-

tional zoning has been based on plans for regional development and relevant legislation. For the first time, such a plan was developed for the environment conservation within the Lake Balaton limits, intended to improve water, atmospheric, soil and other environmental conditions. In the mountain areas of the Crimea (USSR), the recreational limits for camp sites have been established on the basis of the natural stability of ecosystems, relative intensity of the landscape process and the load resistance of primary rocks, relief and plants. The load is considered permissible if it does not go beyond the limits of sustainable conditions of ecosystems which had existed prior to the camp site arrangement.

In Lithuania (USSR), a well-arranged and qualified organization for the preservation of forest recreational capacity and improvement of forestry conditions has been recommended. Functional zoning permits the definition of zones for passive and active recreation, and for cars and reserve zones. Fencing, curtail plantings and fertilizing have proved the most effective of measures for conservation and regeneration of plants as well as for improving the stability of degraded forest ecosystems [99]. Administrative and territorial plans in Poland include such conservation aspects as recreational resources and their conservation and formation as well as natural environment capacity, recreational demand and possibility of its satisfaction, development of a recreational function.

Kenya possesses the greatests number of conserved territories among developing countries and conducts an active policy of nature conservation. There are seventeen national reservations in the country, whose areas exceeds 25,000 hectares. The largest national park, Tsavo, is located in an area of 2.1 million hectares. There is a number of smaller but well-known parks, such as Nakuru island with the largest flamingo colony of the world. Kenya also possesses marine national parks [127]. At the same time, the development of tourism and recreational systems in some cases exerts a negative impact upon both separate components and entire territorial-recreational complexes and ecosystems. Problems of fire control and poaching prevention can also become acute. In June to November, 1977 alone, poachers slaughtered 1,040 elephants, 235 rhinoceros and 20 leopards in the Tsavo reservation.

Negative consequences of tourism include damage to plants, soil cover and plant communities, increased erosion, increased level of noise, water, air and soil pollution, changes in the balance among various flora and fauna species, degradation of the landscape, damage of valuable geological objects, deterioration of recreational attractiveness of the site, etc. Tourism is having an ever-growing negative impact upon fragile ecosystems of islands in Central America and the Indian and Pacific Oceans as well as on the dune beaches in Denmark, Ireland, the Netherlands and the United Kingdom. Tourist influx has gradually changed recreational zones on the Adriatic seaside and many other paradise regions of the world.

These and many other issues were discussed at the First European Conference on Tourism and Environment held in 1979 on Jersey. The Conference focused special attention on the need to study various aspects of tourism at both national and international levels. Concurrent with this, considerable importance was attributed to rational load distribution on vulnerable natural objects, proper distribution of recreationists and tourists, ecologically thought-out construction of hotels, camping, rest facilities and roads, and an increased number of conserved territories as well as on the development of a comprehensive plan of conservation measures for the most vulnerable ecological systems.

Chapter IV

A NEW APPROACH TO STUDIES AND PROTECTION OF THE ENVIRONMENT

*

ECONOMIC DEVELOPMENT

Socio-Economic Factors of Development

In solving environmental problems, the economic, political, social and cultural aspects of progress are of paramount importance. They are based on a series of production relations corresponding to one or another varying ways of generating material value and depend mainly on the flexibility of governments in meeting various social needs. One of the features of such flexibility is a more complete interaction between ecological aspects of the economy and expansion of ever-growing raw material and power basis on the one hand, and increasingly automated labour on the other.

The reason behind this is that even slight violations of rhythms between various ecosystems may and do influence the economic growth rate, effect both the quantity and quality of food, cause human disease which never existed before and hinder the development in living standard of population, especially in developing countries. These and a number of other circumstances compel scientists, government officials and the progressive world public to take a new look at the environment.

But how has scientific and technical progress come into conflict with the environment and development of society? In many ways, conflict stems from erroneous assumptions on a conquest of nature, deeply rooted in the human conscience. Meeting the population's ever-growing material and cultural demand not only involves increasing output and therefore the consumption of minerals, raw materials, energy, land and water resources, but also, to a great extent, stipulated by co-operation with nature. By discovering its laws, man, representing the highest stage of a biological pyramid, is called upon to create and manage the most favourable relationship possible in utilizing environmental components.

In general, the necessity of putting the problem in such a way is quite evident and is prompted by the whole course of development of social relations, regardless of conditions of different social formations. However, a considerable number of philosophers, sociologists, economists and other specialists in various fields see the origins of ecological and economic understanding of certain economic phenomena as dating from the great leap which followed the Second World War, marking a scientific and technological revolution.

The creation of new kinds of materials and energy and the reconstruction of the technical basis of material

production coupled with changes in the type of labour and management have altered earlier concepts as to the extent of the impact of economic activity on various ecosystems. Yet in no way can these be the point of departure or genesis for universal theoretical conclusions and generalizations.

The international aspect of the problem, the necessity for combined effort for the protection and rational use of the environment and the identity, in some instances, of measures directed at re-creating natural resources mask the main reasons behind the ecological and economic interpretation of life-support systems.

The essence of the issue is not in terms of scientific and technical progress itself, but lies in the question of how it is to be achieved, who benefits and whether the environmental protection measures correspond to social changes.

The struggle for survival and the unrestrained drive for profits on maximum production in fact annihilate the demands of people for firm guarantees on their human rights, including the protection of the environment against pollution and exhaustion. Companies and corporations comprising thousands of industrial enterprises, with the help to motor transport and various heating systems, produce harmful and toxic substances which intensively pollute the atmosphere, water bodies and soil, carelessly exploit natural riches and inflict unreparable damage to the economy of the future as well as affect detrimentally human health.

Efforts to take into account ecological aspects within a predicted period of economic development at the level of government-sponsored programmes seem rather problematic. For instance, experts from France, the Federal Republic of Germany and the Netherlands try to base integrated planning on territorial and regional principles, such as urban and rural ones, various communications, municipal economy, visual components of towns and villages, etc.

Doubts were raised as to a successful implementation of the 'Blue Five-Year Plan' on environmental protection adopted by EEC for the period 1977 to 1981. The goal itself, tasks and expected results of this highly optimistic plan represent bright perspectives for the future of the environment and, consequently, of living conditions of population. The plan envisages control of water and air pollution and of noise, monitoring and utilization of wastes, co-operation in conservation, protection of the animal and plant kingdoms, estimation of the effect of production on the environment and compiling an ecological map of Europe. These purposes are also served by "black and grey lists" of harmful substances (mercury, cadmium, organic halogens, organo-phosphorus compounds, carcinogenic, substances, zinc, copper, nickel, chromium, lead, arsenic, molybdenum, tin, uranium, silver, cyanides, fluorine, nitrates, inorganic phosphorus compounds, biocydes, etc.) which prescribe maximum permissible levels of emission and corresponding national standards should be established.

However, realization of these long-term national and international environmental protection programmes encounters serious financial and other difficulties.

Moreover, they scarcely seem feasible owing to further growth of conflicts and contradictions resulting from the fact that implementation of the envisaged large-scale projects requires huge investments.

The new meaning of the notion environment is gradually gaining universal recognition (Fig. 20). At the opening of the Tbilisi Conference, the Director-General of UNESCO, Amadou Mahtar M'Bow, enmphasized that the conception of the environment had under-

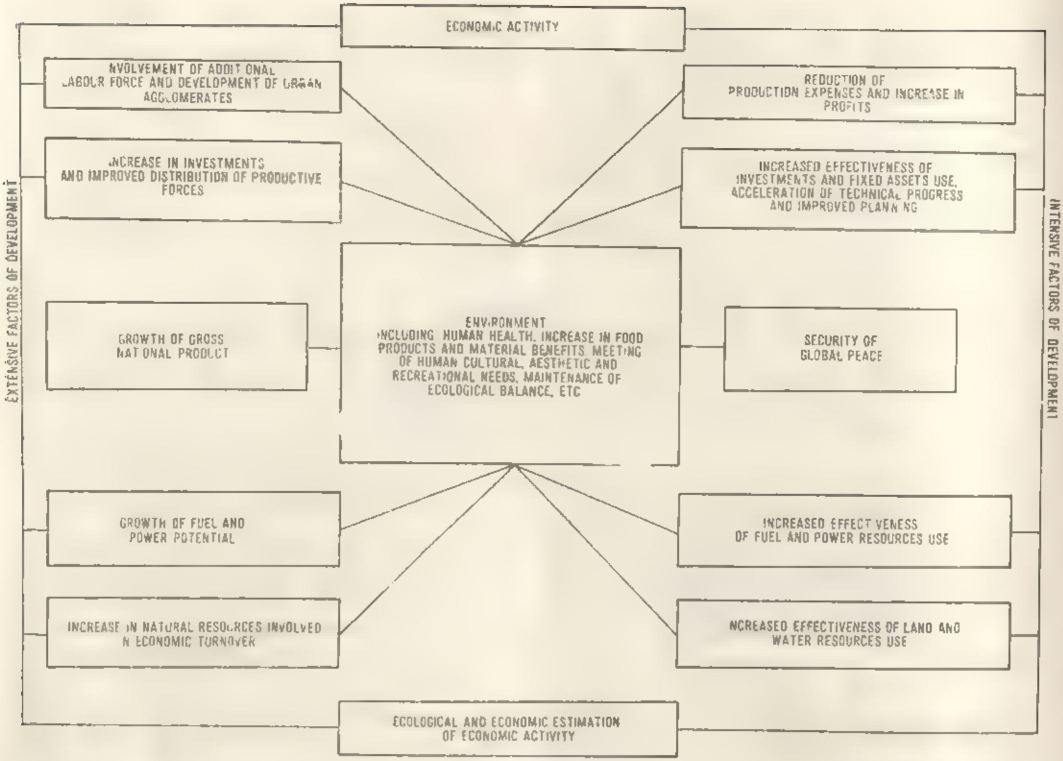

Fig. 20. Relationships between the environment and factors of development.

gone an evolution. From an outlook confined to the physical and biological aspects of the environment, there has been a gradual transition to a broader conception... also [covering] the manmade social, economic and technological environment... protection of the environment is a many-sided task which cannot be carried out without taking account of those socio-economic factors which have usually been the very cause of the problems [3].

In one way or another, this concept was reflected in resolutions of various conferences, e. g., the United Nations Conference on Water Problems in Mar del Plata (Argentina, 1977), the WHO Seminar in Argostolione devoted to an estimation of environmental factors with an impact on the health of population (Greece, 1978), at the Second Session of the Preparatory Committee in New York (1979) and at the Seventh Session of UNEP Manager Council (1979), in the Global Strategy of Environmental Protection adopted by IUCN together with UNEP and WWF (1979), the Stockholm Symposium on Interrelationships Between Resources, Environment, Population and Development (1979), the United Nations Conference on Desertification in Nairobi (Kenya, 1977), the Fifth International Symposium on Ecological Problems of Landscape Research in Bratislava (Czechoslovakia, 1979), etc.

Economic Development and Ecological Problems

In general, the socio-economic trend in environmental problems is common for all nations; however, it has evident distinctions as to its manifestation in industrialized and developing countries. For the former, the notion of environment is associated not only with pure atmospheric air and water bodies and the extent of urbanization, but quite legitimately also with labour, living and housing conditions as well as with quality of food which for numerous populations segments remains unsatisfactory.

In 1977 *, two thirds of the total expenditures on environmental programmes in the United States were shouldered by the private sector. The results of research conducted by the Economic Centre of Public Interests at the request of EPA show that in the United States the share of expenditure on environmental protection in a family budget is inversely proportional to the income. The low-income sector accounts for $ 800 million per year. That is why a pure environment, as a product, should, according to EPA be treated as a luxury.

Such findings quite evidently demonstrate the real nature and subject of the measures taken by the governments of some countries in the sphere of conservation and the carefully masked indifference of monopolies to environmental problems. Ever-growing arms expenditures play their negative role in the living standard of people, sky-rocket food prices and prices of essential goods, increase housing payments and public services fare, reduce spendings on social programmes and boost unemployment.

Only all-encompassing changes of economic systems — rather than revision of financing methods — can solve the pressing environmental problems and turn a pure environment from a luxury into a simple way of meeting the essential needs of all people.

Earlier views of the environment, which in many ways was identified with the use and protection of natural resources, have undergone considerable changes. From a strictly nature-protecting and, to some extent, rather specific notion in economic terms, the term environment in a very short time has broadened. The environment is a capacious and, at the same time, interdisciplinary concept encompassing ecological, physical, scientific and technological aspects of development as well as the socio-economic relations involved in the production process.

The new economic crisis has sharpened the issue of possible ways of economic development and solutions of ecological problems, since the adoption of the necessary effective steps is limited by low annual industrial growth rate, high unemployment and inflation. In Canada, France, the Federal Republic of Germany, Italy, Japan, the United Kingdom, the United States and OECD countries in general, GNP has been reduced, thus creating a gap between environmental protection programmes and projects and real chances for their realization. That is why OECD countries show more restraint in implementing protection policy and in their search for harmony between the necessary economic growth and development [130].

It is expected that in OECD countries the annual economic growth rate between 1978 and 1985 will increase by 3 per cent and pollution by 10 to 25 per cent or more. Maintaining the present structure and character of agricultural production could enhance pollution by 50 per cent for the same period of time. It is not by chance that experts in en-

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* Dorfman R. **Characteristics of Expenditures and Profits of Environmental Protection Programs.** 1977.

vironmental protection and economic development emphasize the need for a more profound approach to the issues associated with nature protection factors in solving the problems of employment, inflation, etc. In their opinion, correct environmental protection policy could moderate slightly the employment problem. For instance, in the United States in 1975 about 1 million people were involved in measures controlling environmental pollution (by 1980, the figure should have increased by 193 thousand). In the Federal Republic of Germany in 1970 to 1979 the ecology-oriented economic policy provided jobs for 586 thousand people, while in France in 1978 alone in the production and attending of instrumentation and pollution control means 173.5 thousand people were employed, including 44.5 thousand engaged in treatment of waste [131].

The concern of the most developing countries is tied up with the necessity to solve social problems of the first priority, i. e., to put an end to poverty, famine, widespread diseases and illiteracy, to raise general culture and to provide favourable conditions for the renovation of natural resources. Since developing countries are still at a low level of development, steady growth of their economic potential based on the rational use of national natural resources and disinterested aid from all countries and people are fundamental conditions for the successful solution of the problems confronting them.

Additional Information

A serious concern with environmental problems is a relatively new phenomenon in modern society. Although there were always some anxieties as to environmental problems, it is only in the last decades, as a result of extremely rapid scientific progress as well as technical and social changes, that new problems have arisen and the old ones look different. At present, it is acknowledged that the combination of various kinds of human activity involve dangerous and, possibly, irreversible consequences. There is also an understanding that some problems, manifesting, themselves in various forms and depending on conditions of individual countries where they occur, may affect mankind as a whole. Moreover, some environmental problems could be exported to other countries through trade and investment measures. A widespread feeling of urgency in solving environmental problems expressed at the United Nations Stockholm Conference of 1972 still exists.

At the same time, there is a pressing need for further development. Poverty in itself degrades the environment. Looking at poverty from this viewpoint, it becomes evident that it is no longer possible to isolate environmental protection with the need for development. In many of the least developed countries, especially in less privileged groups, constituting the overwhelming majority, the protection of the environment depends on development as its prerequisite. Strategies of protection and improvement of the environment ways go along fairly well with development. Both are mutually related and represent inseparable demonstrations of human ability to improve life as well as to ensure the welfare of generations to come. People should use the Earth's resources in such a way as to make possible their transfer to further generations as a heritage, not only preserved but also enriched. This sense of responsibility to generations to come is an important element of understanding environmental problems and its fostering still requires strenuous efforts.

Although a number of measures and initiatives have been put into practice

at national and international levels since the Stockholm Conference, they do not yet meet the needs and hopes expressed in Stockholm. Even though the environmental situation is serious, there are no reasons for unjustified dramatization.

Man is the only creature not bounded by the environment and he can therefore change it. Man is called upon not only to protect but also to improve the environment.

Environmental problems are not limited by the issues of threatening pollution, and irrational use of natural resources. They embrace the problems of underdevelopment, unsatisfactory housing, poor public health conditions, malnutrition, problems stemming from poverty, as well as those of preserving the cultural and historical heritage.

Undoubtedly, science and technology may provide or promote solutions of problems which might have been caused by them. Nevertheless, the solutions to be found should neither be short-lived, not too narrow. In many instances, possible answers should take into account social and cultural factors which often are the roots of these problems. A new look at the complex and delicate relationships between man and his environment is vital to enable man to take the most justified (from an environmental standpoint) course of development.

Natural ecosystems as well as ecosystems already modified by man should help to restore or preserve the necessary balance in the flows of matter and energy. It requires a more profound understanding of the relationships between human activities and various branches of knowledge [129].

Moreover, one must review growth and development patterns and a distinction must be drawn between the notions of what is essential and what is wasteful for the environment and development.

Economic Interests and Natural Sources of Raw Materials

Economic and social interests determine the development of society. One of the conditions of their security is the availability of a natural source of raw materials. Fuel and energy resources, including oil, natural gas, hydraulic power resources and thermal and nuclear energy are considered vital. Extensive use of energy sources, such as solar and geothermal energy, tidal and wind power, appears to be promising for the near future.

The Tenth World Petroleum Congress held in Romania (1979) pointed out that proven world oil resources (USSR excluding) amount to 115,000 million tons, while total potential resources are estimated at 256,000 million tons. Annual global oil output reaches 3,000 million tons and the quantity of petroleum already produced in the world has totalled 48,400 million tons. At this rate of oil production, even shortages have been experienced and for this reason the United States Congress has come forward with the following alternatives to petroleum deficit: increased effectiveness of oil production and more rational use of existing deposits; increased oil production from non-traditional sources and primarily from the oceans replacement of oil in industrial installations by coal or other less deficient energy sources; increased production of synthetic fuel (gas) of liquid motor fuel from coal, shale or petroleum sands; and general saving of energy resources based on the implementation of effective economy incentives [132].

The variants of a combination of economic interests with natural sources of energy development were made more specific by a large group of American experts who, in the process of elaborating the programe 'Energy in the Period of 1985-2010', have underlined the prob-

lematic use of coal as a future energy source. While the factor of high production costs may in this case be of secondary importance, the accumulation in the atmosphere of large quantities of carbon dioxide caused by burning coal is an issue of first priority. At the same time, experts believe that the time interval under consideration will be characterized by an extensive use of non-polluting energy sources (including solar energy) which by the year 2000 will account for 20 per cent of all energy supply in the United States (the share of solar energy even by 2010, obviously, will not exceed 5 per cent) [133].

Weinberg and Rotty agree with this, believing that existing alternative energy strategies do not take into consideration the possible negative consequences of long-term programmes aimed at providing world economy with necessary fuel and energy potential. The use of mineral fuels, which, in their view, may suffice for only 100 to 150 years, carries with it the harmful effect of carbon dioxide emission into the atmosphere and by the 'greenhouse effect'; the utilization of geothermal resources is limited by relatively small reserves, while the use of nuclear energy still involves some risk and unsolved problems of control over thermonuclear fusion.

The problem of fuel and energy resources is especially acute in developing countries where the possibilities of using solar energy are of ever-growing importance. Solar energy use includes hot water supply, steam and electric power generation, recovery of biomass of various waste, etc. Although the future is not clear, there is a trend to use solar energy for hot water supply [135].

One of the promising sources of additional fuel and energy resources is the oceans. According to United Nations estimates, the total area of sedimentary basins and associated gas and oil fields within a shelf region amounts to 20 million square kilometres, while the surface of potential oil fields totals 50 to 80 million square kilometres. It is expected that by the beginning of the twenty-first century, off-shore fields could provide 40 to 50 per cent of world oil production. At the same time, a rise is expected in the ocean's share in the mining of useful minerals, their gross production being estimated at $ 500 million annually. According to some findings, the mining of 1 million tons of concretions covering up to 10 per cent of the ocean bed could provide, per year, 270 thousand tons of manganese, 16 thousand tons of nickel, 13 thousand tons of copper and 2.6 thousand tons of cobalt [136].

Changes in Environmental Pollution

Every year on the Earth 2 to 3 trillion tons of rocks and soils are processed, more than 2,500 million tons of oil and 2,000 million tons of coal are burnt and hundreds of millions of transport vehicles equipped with internal combustion engines are in action. Industry discharges into the atmosphere, water and soil an ever-growing amount of gaseous pollutants and particulates, while agriculture is saturated with an ever-increasing volume of pesticides. Each year some 20,000 million tons of carbon dioxide are emitted into the atmosphere as a result of the burning of oil, coal and other mineral fuel. In 1978, over 1,800 million kilograms, or approximately 0.5 kilogram per inhabitant, of insecticides were used. Nonetheless, insects have adjusted themselves to new conditions, their numbers remain stable and they destroy up to 40 per cent of food products [137].

Pollution with domestic waste also continues to increase. In the United States for example, in 1975, the amount of domestic waste totalled 173 million tons and by 1990 this could reach 197

million tons. In the Federal Republic of Germany in 1978, the quantity of various waste has amounted to 179.7 million tons, including 20 million tons of domestic and similar waste, 36 million tons of municipal slime, 7 million tons of industrial slime, 13 million tons of special industrial waste, and 96 million tons of construction garbage and stripping rocks. In Japan in 1975, the amount of municipal waste reached 32.7 million tons.

Pollution caused by transport vehicle emission is steadily growing. In the United States in 1975, only one third of all cars were in compliance with federal regulations on transport emissions, while half of all the vehicles on the road met no standards whatsoever.

Radiation contamination is also growing dangerously. The United States Committee on Biological Effects of Ionizing Radiation states that effect of radiation on a human organism is proportional to a dose of radiation received, even at low radiation levels. Because of this, there is actually no margin below which radiation effect should be neglected. According to the Committee, the genetic effect of radiation could lead to the fact, that 1 rem, biological roentgen equivalent, causes between five and seventy-five new genetic disorders (in addition to normal 100 thousand per 1 million births). Exposure to 1 rad causes from 192 to 756 possible cancer cases per 1 million men and from 344 to 1031 cancer cases per 1 million women; it raises the number of cancer-caused deaths from 70 to 353 per 1 million annually and from 68 to 293 deaths under the same dose but due to gradual accumulation of irradiation. The planned development of nuclear power engineering in the United States by the year 2000 may result in additional 165-255 cancer-caused deaths per million, to say nothing of future genetic consequences.

In the United States for the period from 1943 to 1980, produced $2.66 \cdot 10^5$ cubic metres radioactive waste of military industry and $2.6 \cdot 10^6$ kilograms radioactive waste of nuclear power plants and by the year 2000 this quantity is expected to rise to $9.8 \cdot 10^7$ kilograms [137, 138].

The intensive pollution of water bodies is well demonstrated by the condition of the Rhine River. The ecological balance in the river area is constantly upset by an ever-growing population, increased energy consumption, the negative influence of the chemical industry and the intensive use of land resources. In Switzerland alone, energy consumption has risen six-fold since 1940, water consumption has reached 1,200 million cubic metres per year and the quantity of the fertilizer produced per year has reached 150 thousand tons. In the last twenty years the content of sulphates in the river has increased by 150 per cent, ammonia by 350 per cent, nitrates and phosphates by 300 to 400 per cent. Deficiency of oxygen in the last twenty-five years has increased 2.5 times. Maximum oxygen shortage (60 per cent) is recorded in various Rhine areas, which means the complete absence of fish in those areas. The number of chemical enterprises, especially, wood-pulp, located in the Rhine basin is 100 times larger than on the banks of any other world river and threatens the water for drinking purposes in the whole basin from the source of the Rhine to its mouth [139].

Concurrently with increasing pollution in industrialized countries, developing countries also experience growing environmental pollution. According to OECD, in 1979 the sulphur dioxide emission in Europe reached the level of 100 Mt annually, or 57 per cent of its global amount. In 1978, emission in Europe of nitrogen dioxide totalled 50 to 60 Mt and in the next decade is expected to increase by 40 per cent. Sulphur dioxide and NO_x extended up to

2 000 kilometres [illegible] degradation of ecological systems [140].

The ecological situation in the Islamic Republic of Iran has seriously worsened. Industrialization without taking into account environmental factors has aggravated the deterioration of various ecological systems and increased the negative impact of large-scale pollution on healthy population. Air pollution in Teheran is five times higher than the permissible level. Industrial emission accounts for 90 per cent of sulphur dioxide, 16 per cent of NO_x, 0.5 per cent of carbon dioxide and 2 per cent of HC, while motor transport account for 98 per cent of HC and carbon monoxide emissions. On the whole, in atmospheric pollution by all sources of emission the motor transport accounts for 86 per cent, industry for 13 per cent and household heating systems for 1 per cent. Water bodies are also severely polluted, including the Ziandrond and Anzali rivers; the Caspian Sea is threatened by a very high level of DDT, mercury and other heavy metals. The content of DDT and mercury in breast milk is five times greater than permissible standards.

In general, the condition of ecological systems in the Persian Gulf area is adversely affected by off-shore oil production, heavy oil tank fleet traffic and possible oil spills, scarce water resources and the high level of their pollution as well as polluting industrial enterprises under foreign ownership and the absence of any measures limiting environmental pollution [141].

[illegible] the number of motor transport vehicles in India is less than in many industrialized countries, the atmospheric air is becoming more and more polluted. In such cities as Calcut[illegible] some cities of the United States. In [illegible] be explained in many ways by India's out-of-date motor fleet and technical maintenance which is far below the world standards [142].

The socio-economic consequences of environmental pollution have an ever-growing negative impact on the health of population. Research indicates that [illegible]zation is directly proportional to lead content in organisms of children, affect[illegible] atmospheric pollution with lead influences the intelligence of children living in urban areas of Australia and the Federal Republic of Germany. In Japan in 1979 there were over 9,000 registered patients suffering from pollution. According to United Nations estimates, in India about 15 per cent of tuberculosis cases are caused by air pollution.

As above, a grave threat to population comes from various toxic substances. In 1977 and 1978, fourteen persons in the State of Nebraska (United States) were poisoned with cucumbers grown by hydroponics. The symptoms [illegible] carbonate pesticide. In 1977 in Jamai[illegible] with bread baked of flour spoiled by [illegible] [143].

According to the United States Cancer Institute, over 60 per cent of all cancer cases, or 500,000 cases per year, are caused by chemicals. Ninety univalent chemicals are considered to be carcinogenic and mutagenous. It is therefore very important that the new chemicals recommended for production every year be carefully checked.

It should be borne in mind that, in [illegible]stered. Because of this, in twenty to thirty years' time, toxic chemicals could infiltrate up to the surface near the places of their burial. The need to

[illegible] ready in use and the 1,000 new chemicals produced each year has become a sore issue [144].

Despite a relative reduction of pollu- [illegible] countries, the total extent of pollution and the quantity of pollutions on the [illegible] harmful factor is the use, in developin [illegible] know-how which do not meet the current world standards in terms of the [illegible] pollution.

Ecological and Economic Estimates of Production

From the economic standpoint, industrial and other influences on the bio- [illegible] vely and qualitatively. The final [illegible] of such assessment is the elaboration [illegible] conservation, protection and improvement of the environment for the purpose of the further development of productive forces and universal regard for the needs of society

Meanwhile, in terms of the ecologi- [illegible] to which all economic p [illegible]

[illegible] relationships established in the process of carrying out technical projects are [illegible] thods aimed either at the elimination of already existing negative consequences, taking into account the actual damage suffered by ecological systems, [illegible] The second group, economists, emphasizes the socio-economic factors as well as the results of carrying out projects dealing with construction or reconstruction of industrial enterprises [151].

The expediency of ecological and economic evaluation of the technologies under design as a conclusion of their impact on the environment has been established in a number of other countries. In the Netherlands and Belgium, it has been used in the elaboration of [illegible] with the exploitation of natural resources, and industrial and road construc- [illegible] manual is being carried out by the [illegible] aboratory specializing in [illegible]

The United State National Council [illegible] establishment of unified [illegible] contents, volume and procedure for elaborating a conclusion on the effects on [illegible] ion documentation for their construction. In the United States, since 1979, such assessment has been made for all state-financed projects and programmes abroad in order to take into account the ecological aspects of the Government's foreign economic activity. [illegible]

scale programmes and projects considerably affecting the environment in foreign countries. In the first instance, the conclusion is prepared following general rules. In the second, the conclusion is compiled under the following conditions: when a country where the work is carried out is not a party to an agreement, for instance, in the case where construction of a dam in one country leads to reduced flow in the other; in the case of the United States delivering installations requiring stringent control, e. g., supply of nuclear reactors, but no nuclear fuel; when realization of a project causes discharge of pollutants gravely threatening the environment and public health; or when the work involves upsetting natural resources and ecological systems on a global scale [153].

Certain unco-ordinated research and attempts to determine quantitatively the impact of economic activity on the environment are currently under way in other countries as well. However, they cannot serve as a basis for the elaboration of a single unified technique featuring the extent of influence of economic development on ecological systems as well as the limits of permissible risk. It is very important to assess potential damage from environmental pollution, thus making it possible to outline particular ways for its normalization and to determine the amount of investment without which (over a period of time) the reproduction of natural resources becomes impossible.

The strategy of long-term development of natural resources in harmony with programme demands for their complex use and reduction to the minimum of the negative impact on living conditions has predetermined the search for fundamentally new ways of taking into account ecological and economic factors in development of the productive forces of society. Their purpose is to prevent miscalculations, avoid the making of unjustified (from an ecological standpoint) managerial decisions and thereby to substantially promote the preventive functions of environmental economics with regard to pollution, exhaustion and extinction of some components of the natural stock. Even today, despite the efforts of some countries to adjust through legal and economic measures the relationship with ecological systems in the process of elaborating scientific and technological development programmes for one or another branch of economy, the environmental aspects of designing and capital construction are often covered too formally and without proper reasoning. What is more, the coverage is done sporadically and, as a rule, is incomplete.

Most countries circulate tens and hundreds of instructions which, from the viewpoint of economy, law and public health, govern the use of one or another resource. However, there is still no universal, generalized document allowing one to judge, with sufficient reliability, the ecological and economic effectiveness of one or another development pattern. There are also no approved criteria ensuring the co-ordination of ecological and economic factors of production in the process of designing an industrial complex, which results in contradictions between technical progress and the goals of environmental protection.

It is generally recognized that, after confirmation of preliminary estimation, initiation of construction, financing and launching of construction and assembly works, the permissible changes in the design are usually very few and they do not seriously affect the final results. At the same time, at the design stage, these possibilities can be much broader and could considerably influence both the preliminary estimation of the project and the changes in ecological conditions of the region. That is why

the most effective means of taking into account socio-economic and ecological effects of economic activity is the organization of a comprehensive ecological examination (assessment) of projects involving exacting requirements on planning and design establishments so as to prevent and reduce to a minimum any negative environmental impact and ensure eventual savings by eliminating the need for future investment to compensate for losses incurred through the irrational use of natural resources and other environmental deterioration.

The comprehensive ecological examination envisages the organization of special commissions of experts called upon to verify, analyse and assess the condition of the environment in the planned area of construction or reconstruction of an installation, observance and provision for conservation, including recreating physically used resources: land and water by taking part in water management in the area neighbouring with industrial enterprises, air by planting tree belts in the same area, etc.; observance of norms and regulations on reclamation of land, on conservation and rational use of fertile soil layer, compensation of losses suffered by farmers through withdrawal or temporary occupation of their parcels of land as well as of agricultural losses; expediency, from the standpoint of preservation of the ecological state of the territory, of selecting parcels of land for siting production; availability of measures forbidding pollution of the atmosphere, water bodies and soil with emission and sewage in compliance with norms and regulations in force on the maximum permissible emission and concentration of harmful substances; grounds for suggested designs in the view of the latest scientific and technological developments in environmental protection; the extent of complex utilization of by-products and industrial waste; expediency and necessity of the installation from the viewpoint of public health and availability of measures preventing water and wind erosion, secondary salinization, desiccation, saturation with ground water and pollution with industrial waste; possibilities for preventing pollution of underground and surface waters with harmful discharge, for using water in a closed cycle as well as construction and operation of highly effective treatment facilities; possibilities for preventing atmospheric pollution with gas emission and the need to use highly efficient scrubbing facilities; compliance with the approved standard projects and specifications as well as a number of other issues associated in one way or another with environmental problems.

Ecological and economic assessments of productive installations are virtually inseparable. Their implementation and combined use in designs are rather difficult, but essential for more accurate warning and the prevention of possible negative effects in ecological systems, for improving the quality of the use of nature and for taking into account environmental factors in economic activity at the stage of current and long-term planning.

Ecological and economic assessments determine the prospect of relationships with the environment. The conclusion as to ecological expediency of a design should therefore be drawn on the basis of expected production output in the estimated year, for which, in every case, that year should be taken demonstrating in the extreme unforeseen anthropogenic effects on various types of ecological systems.

Ecological and economic assessments also envisage the calculation of potential losses which could be divided among the following groups: cost of output reduction as a result of pollution, exhaustion and destruction of natural resources; cost of eliminating and monitoring pollution; additional spend-

ing due to unco-ordinated use of useful minerals during mining, dressing, processing and waste utilization; additional expenditures for social insurance and public health care caused by irrational use of the environment; and unpredictable losses (for instance, natural disasters, etc.).

Such an enlarged classification of losses with their further specification according to branches of the economy most fully meets the basic principles of comprehensive ecological and economic assessment and its fundamental criterion, the sense of which consists in continuous improvement of socio-economic conditions of human activity. In other words, the matter refers to the extent of adherence to public health standards presently in force and those being elaborated on the permissible impact of technological, chemical, physical factors and their combinations on the human organism as a main component of all ecosystems.

Protection and Rational Use of the Environment as Prerequisite of Development

The levelling of differences in economic development requires ever-growing involvement of environmental resources in the sphere of material production. The question has been raised as to the adequacy of natural resources for such a rate of economic growth as would make it possible to bridge the gap in living standards among countries throughout the world.

The solution of such a complex problem is an integral part of studies dealing with the interaction between ecological processes and economic growth in the socio-economic development of the world. Among the first to focus world attention on this problem was the Club of Rome. Based on figures for world population, capital investment, use of non-renewable natural resources, environmental pollution, food production, etc., it called the attention of world's community, governmental and non-governmental establishments and institutions to the urgent need for drastic measures of control over the rate of economic expansion as well as for the elaboration of joint recommendations for the future development of world economy.

According to A. Peccei, Chairman of the Club of Rome, **Limits of Growth** * was by no means intended to forecast or prescribe anything. Its goal was more of an educational and warning character, to identify the catastrophic consequences inherent in existing trends and to stimulate political changes which would help to avoid them. Having warned people in time and given them a chance to see how they rush to the abyss, it is possible to prepare mankind for the need of urgent changes. However, the project specifies neither the character of these changes nor the goals to be attained. It presented a general view of our planet, comparable to a photograph taken from a satellite, and not allowing any definite recommendations to be given. Aggregated at planet level, the indicators featuring the growth of population and industrial production as well as an average level of environmental pollution, food consumption and exhaustion of natural resources were adequate for demonstrating the general condition of mankind, but apparently useless for the elaboration of political programmes acceptable to all countries.

Some 'admirers of unlimited growth' have simply refused to acknowledge any boundaries to human expansion, thus finding themselves in a rather awkward situation, others preferred an intellectual terror and charged the report and

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* Meadows, D. **Limits of Growth**, Report to the Club of Rome, March 1972.

the Club of Rome itself with propaganda of 'zero growth'. It is quite obvious that these people have failed to grasp either the ideas of the Club of Rome or of growth itself. The notion of zero growth is primitive and vague, as is the notion of unlimited growth, and therefore it is simply silly to talk about such matters when dealing with the living dynamic world [33].

The conclusions arrived at by the Club of Rome have paved the way for basic scientific research in the field of global economic development. The most significant work of recent years has been **The Future of World Economy** written by a team of scientists from Brandeis and Harvard Universities, headed by V. Leontiev, under the auspices of the United Nations.

By thoroughly investigating various solutions of global ecological, demographic, agricultural, food and environmental pollution problems, by studying the alternatives of growth as a whole, development of international financial relations and trade, the authors elaborated a long-term pattern of socio-economic development for the world which consists of eight different scenarios. These scenarios, as an obligatory condition of economic development, feature possible answers to the problem of the adequacy of natural resources, possible strategic trends in technical progress, industrialization and the growth of agricultural production, particularly in underdeveloped countries. Having estimated the reserve of mineral resources positively by the year 2000 as sufficient for ensuring relatively high rates of world economic development, the United Nations experts, however, emphasized the factor of rise in cost of minerals extraction that could reduce production rates in these branches of industry.

In their opinion, until the year 2000, the world's demand for copper will increase by a factor of 4.8, bauxites and zinc — 4.2, nickel — 4.3, lead — 5.3, iron ore — 4.7, oil — 5.2, natural gas — 4.5, and coal — 5. These estimates take into account, as far as possible, the effect of future technologies on the development of resources and their consumption, as well as the potential saving of primary resources by increasing the extent of their regeneration. The maximum possible level of reutilization of many materials is 55 per cent, and under continuing increase, it is believed that by the end of the century this will be achieved in all regions. Despite new and more rational and economic ways of raw material utilization, it is expected that in the remaining two decades of this century world consumption of minerals will be three to four times greater that for all foregoing centuries of civilization [93].

At the same time, it is difficult to accurately estimate future natural resources and future demand for materials. Some experts believe that by the end of the century only two kinds of metal ore, namely, lead and zinc, will be exhausted, while other experts add gold, mercury, phosphorus, silver, tin, tungsten and asbestos to the list.

Among energy resources, coal is available in relatively abundant quantities, according to even pessimistic estimates, while available natural gas covers only the necessary part of energy needs in developing countries. As far as oil is concerned, the data available show that world oil reserves exceed by a factor of 1.3 the expected total demand for it up to the year 2000; the prospected world reserves of metal minerals and liquid fuel, on the whole, are sufficient to meet world demand in the remaining decades of this century and possibly the beginning of the twenty-first century. However, adequate distribution of these minerals does not rule out a shortage of them in some areas, as well as high prices; it also does not guarantee basic economic transition to

dependence on oil shale, the gasification of coal and on other new energy sources.

The analysis of regional distribution has indicated that, if new large deposits are not discovered, then Western and Eastern Europe, Latin America (average income), arid Africa and Asian countries, which have no oil, could in the foreseeable future become importers of most basic minerals. Because of difficulties with their balance of payments, in order to ensure economic growth these regions should attach primary importance to prospecting deposits of useful minerals. This is especially true for the oil-poor countries of Asia and Africa, as well as for some areas of Latin America [93].

Environment and Internationalization of a New Economic Order

The first steps in the reconstruction of international economic relations between industrialized and developing countries on the basis of socio-economic and ecological factors of their growth on equitable and mutually beneficial principles were undertaken in 1968 at the Intergovernmental Conference on Rational Use and Protection of Biosphere Resources (Paris, 1968).

Decisions taken at this international forum specifically underlined the following: taking into consideration that developing countries are not able to ensure their socio-economic growth without rational use of renewable and non-renewable natural resources; stressing that the produce of farming; cattle-breeding, fishery and forestry, which is a basis of these countries' economic development, has to grow rapidly to meet population increase and the need for improved living standards; taking into account also great expectations in most of these countries for regional co-operation aimed at the joint use of natural resources, when the construction of dams makes it possible to develop irrigated agriculture, shipping and to supply electric power for industry; fearing that intensive exploitation of natural resources in these countries could cause irreversible changes in the environment which, although intact for the time being, has a very sensitive and delicate balance; and taking into account lack of human, material and financial resources in these countries which hinders successful use of the environment, provided that the fundamental components of the biosphere are preserved on a scientific basis, the Conference recommended:

— that projects for developing countries (at the stage when investments are not yet confirmed) carried out by special UN establishments should give due regard to all recommendations put forward by the Conference as to the character of the projects, eligible experts, granting of scholarships and equipment deliveries. All this is also relevant to capital investments financed from loans granted by the World Bank;

— the ecological interrelationships should receive due consideration in all major development projects;

— that all international organizations constantly focus the attention of the governments, when considering their requests for aid, on possible far-reaching and long-term consequences of violation of environmental ecology;

— that these organizations should take the necessary measures to pay special attention to development of regional projects which are in the best interests of several countries and to possible simplify the procedure of their realization [156].

Further development of the above recommendations was reflected in the Fune's report, **Development and Envi-**

ronment, which laid the grounds for the Stockholm Conference Resolution. The report particularly stressed that, both in urban and rural areas, not only living standards but life itself is jeopardized by an unsatisfactory water supply, poor housing conditions, neglected public health requirements, undernourishment, starvation and disease as well as natural disasters. In view of the environmental problems, these issues require no less consideration than does industrial pollution; they are the problems that affect the lives of the majority of mankind [157].

The specificity of various environmental aspects was expanded upon in the Conference Declaration; the need for an integral and comprehensive solution to them, accompanied by the implementation of various forms of international economic co-operation was underlined. In developing countries, the Declaration's foreword stressed, most problems stem from their low level of development. Therefore, developing countries should direct all their efforts towards development, but a development based on their essential goals and the need to preserve and improve the quality of the environment [158].

As the role of developing countries in solving the burning issues of our days grows in conjunction with the increasing impact of socio-economic and ecological environmental factors on the domestic and foreign policy of the majority of Asian, African and Latin American nations, the question of reconstructing economic norms of international co-operation on a more equal and just basis has been raised. This viewpoint was supported by many United Nations Member States and, in 1974, following the initiative of more than ninety developing countries, the Sixth Special Session of the United Nations General Assembly adopted a resolution calling for the establishment of a new economic order.

The basic principles and demands concerning the reconstruction of international economic relations were reflected in the "Declaration on Establishment of a New International Economic Order", and the "Programme of Actions for Establishing of a New Economic Order", adopted by the session.

The pivotal paragraphs of this Programme are as follows:

— adoption of urgent economic and legal international documents securing the national interests of developing countries in the process of exploitation of their natural resources, particularly non-renewable resources;

— redistribution of the world's gross social product favouring developing countries and serving to compensate financially the losses suffered from increased production expenses, high raw material prices and boosting inflation;

— establishment of a preferential regime for developing countries within a system of international economic relations.

Further guidelines concerning the fundamental paragraphs of the Programme for Establishing of a New Economic Order were continued in the "Charter of Rights and Obligations of States", adopted at the Nineteenth Session of the United Nations General Assembly (1975); in the Dakar Declaration and Programme of Actions on Problems of Raw Materials (1975); in the Lima Declaration and Plan of Actions on Industrialization and Co-operation (1975); in the resolution of the Seventh Special Session of the United Nations General Assembly "Development and International Economic Co-operation" (1975); in the Manila Declaration on International Trade (1976); at the Fifth Conference of Heads of Non-Aligned States, and in a number of other international documents.

But despite the urgency of the problems raised by developing countries,

decisions of the United Nations General Assembly and decolonization, some countries are reluctant to yield in such economically important issues for developing co-operation, as the relaxation of trade barriers and granting to countries of Asia, Africa and Latin America broader access to Western markets, stabilization of prices for goods from developing countries, increased share of real resources of these countries used for improving their national economics and steady levelling of their economic situation. The problem of establishing developing countries' permanent sovereignty over their own natural resources is quite painful [123].

The above, aggravated by the desperate lack of qualified specialists and necessary amount of investments for rational use of natural resources, the low level of economy any production management as a whole, paved the way for internationalization of a new economic order taking the form of expansion of economic co-operation and co-ordination of efforts of developing countries directed against neo-colonial policy and the wasteful and depredatory exploitation of national riches of developing countries.

Bilateral and multilateral agreements on various environmental aspects and formation of authoritative intergovernmental associations, organizations and subregional groups are important steps in this internationalization. Among those worth mentioning are: in Latin America, "Treaty on La Plata River Basin", "Andean Group", Committee on Natural Resources and Preservation of the Environment; etc.; in Africa, Organization for Development of Senegal River, East African Association and its subsidiary bodies; in the Middle East, Organization of Petroleum Exporting Countries (OPEC), Arab Organization for Agricultural Development, Inter-Arab Tourist Union, Arab Fund of Economic and Social Development, Arab League, etc.; in Asia, Association of South-East Nations (ASEAN), Regional Co-operation for Development (RCD), etc.; in Latin America, Economic Commission — ECLA, and a number of others.

MANAGEMENT OF ENVIRONMENTAL PROTECTION

National Characteristics of Interaction Between Society and the Environment

National characteristics of interaction with the environment depend on a number of factors: natural geographic and climatic conditions, population quantity and urbanization, level of technology development, degree of meeting the socio-economic needs of population, mode of production of material values and level of economic development, level of use of natural resources, state of environmental protection law and level of economic control of conservation, national traditions in relation with the environment and the state of environmental education and culture. In every case, these factors take a variety of forms and depend considerably on the skillful combination of legal, administrative and economic measures determining national policy relating to the protection and rational use of the environment.

In developed countries the relationships between society and the environment generally occur under the influence of large-scale pollution; the high specific weight of oil and gas in the fuel-and-power balance; high level of nuclear industry development and increasing extent of thermal and radioactive pollution; ever-growing stress on the environment; power, ecological and water crises; ever-

growing extent of motorization; high population density and state of economic development in a territory; and an expanding industrial agglomeration.

The national environmental policy of developing countries is affected by a low level of their economic development, especially in agriculture. The availability of water resources plays a vital role in realization of their environmental policy.

Policy of Developing Countries in the Field of Environmental Protection

In the opinion of Nesterov, the four most common trends in the policy of developing countries in the field of environmental protection are: an increase in the productivity of agricultural and other ecosystems on the basis of implementing ecologically grounded intensive management methods in farming, cattle breeding, forestry and fishery; complex measures aimed at controlling soil erosion; desertification and the exhaustion of water resources and at preserving forests; setting up of agro-industrial complexes using local raw materials along with wastes and by-products of production; and the protection of nature by expanding the network of protected territories.

An important role in the nature conservation policy of developing countries is played by the services forecasting natural disasters (droughts, cyclones, floods, fires, onslaught of migratory desert locust, etc.) in order to minimize their devastating effects, programmes on eliminating centres of dangerous diseases and weather control measures which contribute to decreasing the economic dependence of developing countries on adverse natural forces and phenomena [167].

Other aspects of environmental protection policy of developing countries include the accelerated development of science and technology, and the implementation of co-ordinated scientific and technical policy both at the national and regional levels; the development of a national material and technical base for industry and agriculture; the development and improvement of national legislation, including standardization and normalization; closer correlation of development plans with socio-economic problems; training of national personnel; the development of education at all levels of training and advancing of skill; the rational combination of the modern achievements of scientific and technical progress, international aid and national researches; and the development of international co-operation, including co-operation under the auspices of UNESCO and UNEP.

Furthermore, in developing countries, there are many other approaches to current environmental problems. They depend on local socio-economic and natural conditions. In some countries, natural degradation processes are of a clearly pronounced character; in others, they are at initial stages of their development.

In Brazil, for instance, the growth of industry results in an increased volume of pollution. The greatest damage to the environment is caused by power engineering, ferrous metallurgy, cement, chemical and mining industries. Foreign companies holding leading positions in industry exert an especially harmful effect: of the hundred largest companies, fifty-nine are owned or controlled by foreign capital [168].

Ecological problems in Jamaica are particularly critical, associated with urbanization and erosion processes, problems of irrigation farming, tourism and pollution. Pollution of the Kingston harbour with industrial and domestic sewage resulted in a content of organic substances in harbour water 60 to 70 times higher than that in the ocean waters. There are practically no food fish

species or common shrimps in the harbour.

Pollution of coastal waters with domestic waste may lead to the extermination of the barrier reef corals, which would have a negative effect on the littoral zones' hydrodynamic properties and would result in destruction of 10 kilometres of beach [169]. The National Board for Natural Resources Conservation of Jamaica conducts a policy aimed at controlling these negative pollution after-effects.

In Venezuela, reserves of valuable wood species are continuously reduced. The main forms of forest resources use are long-term concession, two-year contracts and yearly licences. The last form is gradually being forced out as special forest reserves, area 12 million hectares, are organized. The expansion of areas under coniferous tropical species, especially slash pine, plays a great part in afforestation. Twenty-six forest nurseries yielding 6 million saplings annually have been organized in the country [170].

Forest areas are being reduced in Colombia as well: up to 2 million hectares of forest are devastated annually, which results in wildlife extermination. At present, more than 1 million hectares of forest are reserved, and eucalyptus planting aimed at soil layer preservation in felling areas is one of the most important activities of the National Board for Nature Conservation [171].

In Papua-New Guinea, the predominance of the lealand farming system couples with the growth in population result in the annual burning of about 20,000 hectares of forest. The organization of large plantations of export crops is very harmful to forests. Projects for creating plantations of exotic species represent a serious danger to forests, because they also lead to forest plant destruction [172].

In Australia, urbanization factors, growth in minerals output, forest felling and a high stocking rate of grazing grounds cause a constant increase in the area of arid regions; deserts and semideserts occupy almost 74 per cent of the country's territory. For desertification control, the creation of forest shelter belts around towns, a zigzag arrangement of roads and buildings to weaken the wind force and dump fastening with plants and rock debris have been recommended; in the country-side, replacing annual fodder crops with perennial ones and controlling the stocking rate of grazing grounds have been recommended [173].

A more complete utilization of solar energy to meet energy requirements is seen as a promising line for improving the ecological situation in Australia. In 1977, there were about 30,000 solar energy converting plants in operation. One task at present is the development, by means of solar energy, of a liquid fuel for transport needs instead of oil, which might reduce considerably the demand for wood [174].

In the Philippines, environmental problems include non-planned urbanization, the exploitation of resources by forest and mining industries enterprises and pollution with industrial, transport, agricultural and municipal domestic waste. In 1969 to 1974, the annual reduction of the forest area accounted for 204,000 hectares. Fish stunned by dynamite explosives and electric current, particularly in Lake Luzon, and the application of toxic agents, resulted in a sharp decrease in the catch in Mindoro and Mindanao Islands. To eliminate these and other negative factors, it has been suggested that measures be taken for afforestation in the area of 750,000 hectares, that comprehensive study of the biology and ecology of rare endemic animals and plants be carried out and the information so obtained applied extensively and that monitoring be organized.

Anthropogenic activity has also af-

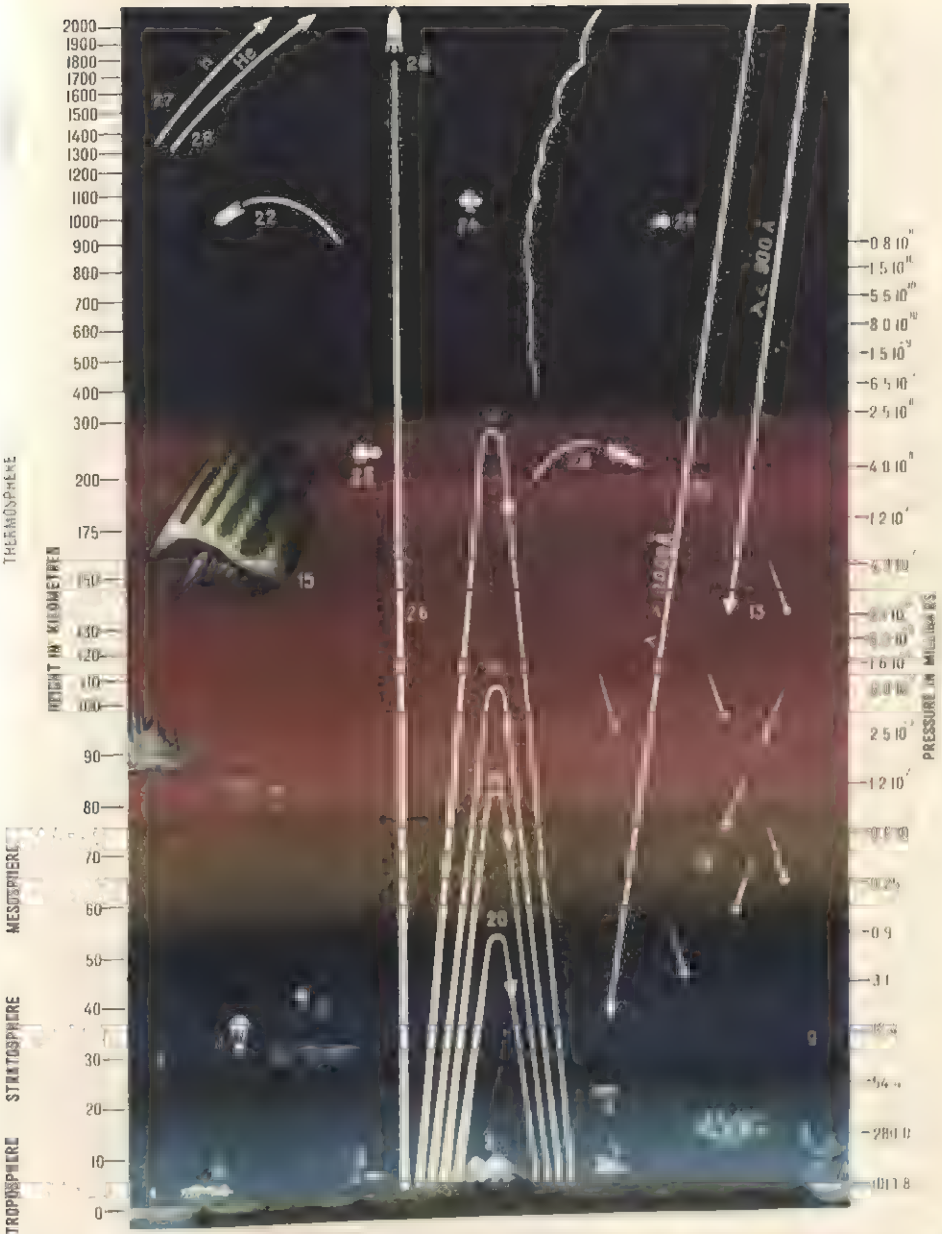


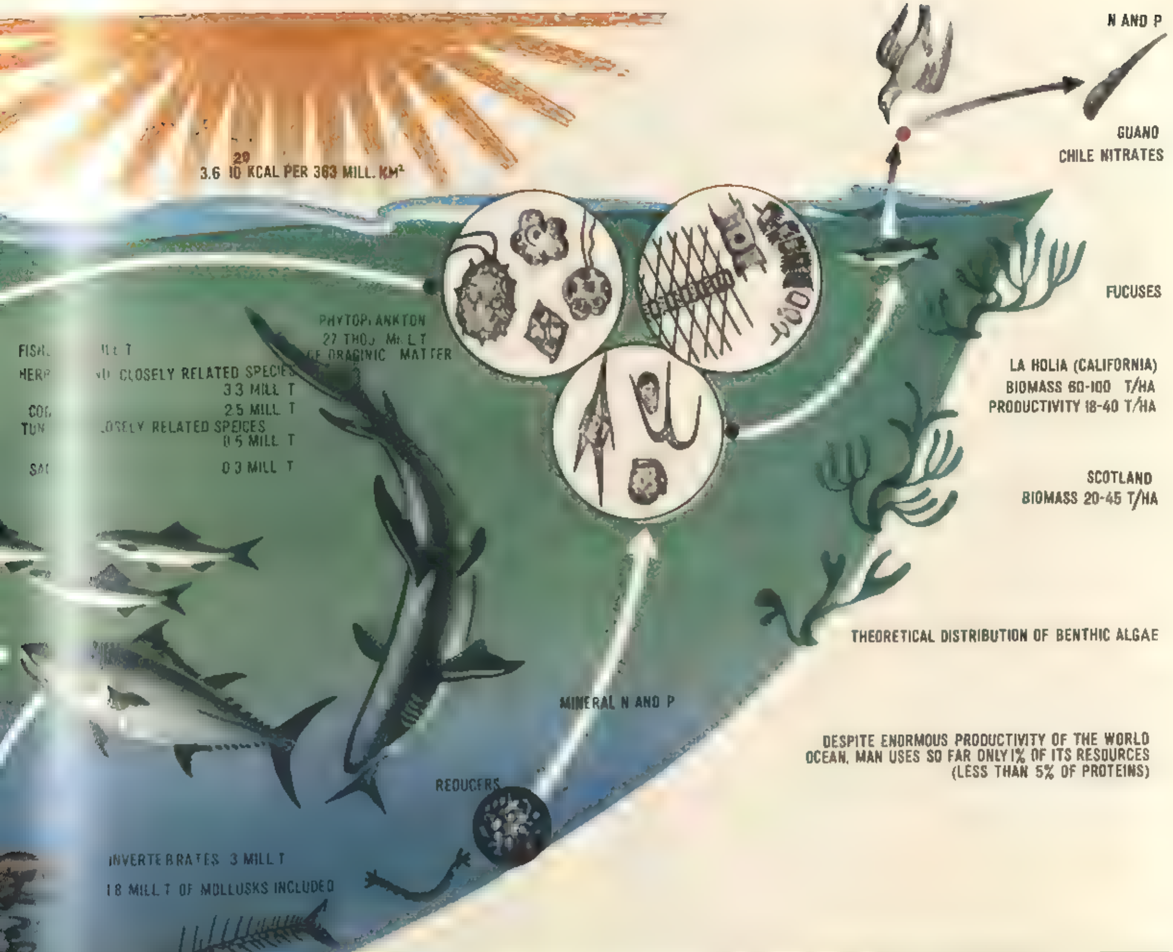
Fig. 15. Diagram of the atmosphere structure (according to Budyko, Kondratiev, 1970):

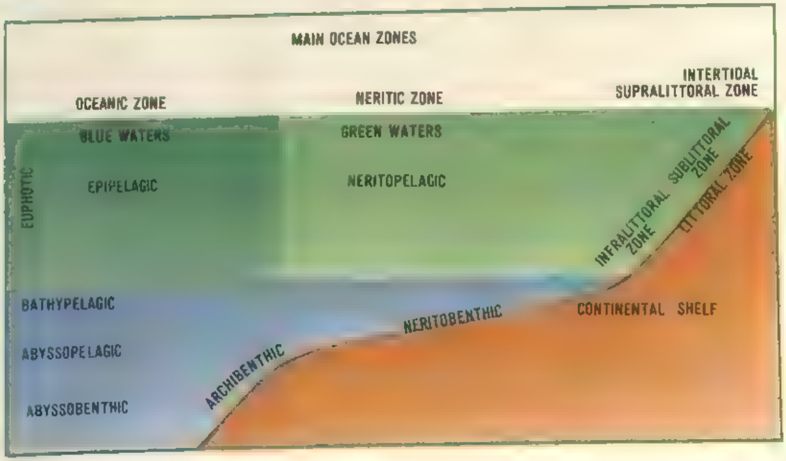
1 — sea level; 2 — Chomo-lungma (Everest), the highest point on the Earth, 8848 m, 3 — cumulus clouds of good weather; 4 — big cumulus clouds; 5 — shower (thunderstorm) clouds, 6 — stratorain clouds, 7 — spindrift clouds, 8 — plane; 9 — layer of maximum ozone concentration; 10 — pearl clouds, 11 — stratostat; 12 — radiosonde; 13 — meteors; 14 — luminescent clouds, 15 — polar light, 16 — American missile plane X 15, 17, 18, 19 — radio waves reflected from ionized layers and coming back to the Earth, 20 — sound wave reflected from a thermal layer and coming back to the Earth; 21 — first Soviet artificial Earth satellite, 22 — intercontinental ballistic missile, 23 — geophysical research missiles; 24 — meteorological satellites, 25 — Soyuz 4 and Soyuz 5 spaceships, 26 — space missiles leaving the atmosphere limits as well as radio wave penetrating ionized layers and leaving the atmosphere; 27, 28 — dissipation (slipping away) of H and He atoms; 29 — trajectory of solar fluxes P; 30 — penetration of ultraviolet rays (λ>2000 Å and λ<900 A wave-lengths)

Musk ox

European bison

Fig. 17. Ocean ecological system





AND A LARGE MOUTH WHICH ALLOWS THEM TO COPE WITH A LARGE PREY. MANY BIOGENIC ELEMENTS (N AND P FOR EXAMPLE) ARE TRANSFORMED INTO ORGANIC MATTER WHICH GRADUALLY DISSAPEAR LEAVING SURFACE LAYERS FOR THE ABYSSAL DEPTH, THUS ACCUMULATING IN BOTTOM SEDIMENTS.

(according to Duvigneaud, Tanghe, 1967)

Black Sea bottle-nosed dolphin

Whistling swan

White-naped crane

Eagle owl

Wolf

Markhor

[illegible] many Pacific Islands (Samoa, Midway, Guam, Nauru, Tokelau, Tonga) where population density is more than 100 people per 1 square kilometre. After the Second World War, to overcome economic difficulties, the governments of many islands tried to develop tourism, which later had a detrimental effect on nature and landscape of the islands. Organic and domestic pollution, sewage and oil waste have converted Pago Pago Bay (Eastern Samoa) into a storage of turbid sludge water, which has destroyed coral in the greater part of the coastal zone.

Excessive hunting threatens crocodiles, sea turtles and whales with extinction. The degree of admissible modification of natural ecosystems in the Pacific Islands has not been sufficiently studied; however, in many cases, the changes occurring are irreversible. When developing environmental protective measures, therefore, not only established cultural traditions of the local population, but also the [illegible] resources of the islanders and the impact of anthropogenic pressure on ecological systems must be taken into consideration [175].

Environmental problems facing developing countries and ways of [illegible] them can be exemplified by India where, by the year [illegible] the population is expected to increase almost [illegible]. The most urgent problems are [illegible] pollution, [illegible] of water resources, the [illegible] mination and [illegible] station, soil erosion, disappearance of some plant and animal species and the [illegible] conditions of [illegible] and [illegible].

Atmospheric air pollution in India is typical of town and rural settlements where firewood and [illegible] wastes are widely used for fuel, which, in turn, involves many [illegible] ust emission of [illegible] port, because of low quality of engines and [illegible] 2 to 3 times higher than that in industrialized countries. These and some other factors result in atmospheric pollution in most big cities of India being much higher than generally [illegible] standards [illegible].

In the future, the main type of fuel in the country will be local low-sulphur coal containing up to 40 per cent ash and whose output by the year [illegible] will increase approximately up to 545 million tons (the 1973—1974 output was 77 million tons). A five- and six-fold increase is planned for the capacities of the wood-pulp and paper as well as chemical industries, respectively as compared to the 1966 to 1969 period. Water intake will grow almost 10 times and exceed 20,000 million cubic metres.

In the country-side, only 5 per cent of India's population has tap water. A sewer system is available for only [illegible] per cent of the urban population. About [illegible] per cent of [illegible] suffer from helminths, and generally in India [illegible] sewer conditions initiate half of the disease cases. By the year 2000, a centr[illegible]

In India, there are 21,000 higher plants [illegible] of the area, and special measures are [illegible] tection

Improvement of national environ[illegible]

Solutions to environmental problems [illegible] natural

mineral and raw material resources, levels of economic development and methods of meeting the primary needs of the population in terms of food, housing, etc. Because most countries of Asia, Africa and Latin America are among the poorest countries of the planet, it is quite natural that, first and foremost, preference be given to the vital problems of hunger and poverty, i. e. to solution of the most urgent survival problems.

Statistics and Planning of Environmental Protection

Environmental protection statistics are called upon to ensure the solution for a wide range of integrated problems relevant to natural, created and social components of society life. The basic tasks of statistics are: constant study of population needs and resources available to meet them, verification and analysis of planned environmental protection indicators; data processing and classification; elaboration of definite recommendations for improvement of one or another environmental aspect.

Environmental statistics, depending on the goals, scale, ecological geographical, socio-economic, sanitary and hygienic aspects of the problem under study, rely on various data derived from different kinds of monitoring systems, cadastres, satellite observations, surveys, integrated data funds, mapping of natural surroundings, statistical reports by companies and sectors of the economy, reviews, inventories, etc.

Monitoring is a special information system of repeated observation of various environmental elements in space and time. The main purposes of monitoring are: determining the quality of the environment and trends in its change; providing warning as to possible dangers to the environment from the impact of society; verification of the effectiveness of environmental socio-economic policy of states as well as of implementation of adopted programmes. According to Izrael, environmental and climate monitoring is aimed at continuous control of the energy balance and accumulation of superfluous entropy in systems and verification of the conformity of the level of system organization to the organization level of the environment rather than detection of negative impacts of human activity [177].

There are five types of monitoring: global, ecological, air-space, complex and local. The concept of global environmental monitoring was formulated for the first time in the early 1970s in the scientific report **Global Environmental Monitoring**, presented by United Nations. Later, a number of international programmes and organizations engaged in monitoring were established, including GEMS, with its centre in Nairobi (Kenya), the Global Environmental Monitoring System within the CMEA framework, the Research Institute on Environmental Monitoring within the United Nations framework, national monitoring programmes, etc. Global environmental monitoring activities encompass climate-related monitoring, monitoring of long-range pollutant transmission and sedimentation, health-related monitoring, renewable resource monitoring and ocean monitoring.

Ecological monitoring does not suggest constant observation of all biological elements. It relates only to structural characteristics of communities as a whole, their total biomass or characteristics of functioning. Such ecological monitoring is less expensive and more effective than observation of some species of animals or plants [178].

The air-space monitoring is a system for observation and monitoring of the environment as well as for control over its condition through remote indication. The techniques for decoding the dynamics of ecosystems' morphostructure are divided into interpretative and correla-

tive ones. Interpretative techniques give qualitative characteristics of the dynamics by photos taken during one flight, while correlative ones ensure quantitative analysis of the dynamics by comparing air-space documents and charts taken at different times. Air-space monitoring provides a rapid and broad cartographic representation of data on the composition, rate and distribution of current dynamics of ecosystems [179].

Local monitoring envisages constant supervision of some ecological areas for analyzing natural resources quality, for determining its compliance with the requirements of laws and standards, for analyzing the effectiveness of measures being implemented and for devising research programmes.

In the United States, water resource monitoring is based on data supplied by 200,000 monitoring stations and a united automatic data storage system. Since 1964, EPA uses the STORET System, which stores information on 1,800 parameters of water quality. Some 85 per cent of all information embraces 187 basic parameters; 17 parameters are used by EPA for establishing water quality standards [180].

Existing United States programmes on monitoring underground waters are aimed at determining their quality and quantity for various consumption purposes by analyzing samples from check wells. To implement programmes for the prevention of underground water pollution, EPA has elaborated a comprehensive methodology for the identification of the main sources and kinds of pollution, comprising: determination of a region to be monitored, identification of sources of pollutions and methods of waste disposal, identification of potential pollutants, determination of main kinds of underground waters consumption; study of hydrological regime of a territory, determination of underground waters quality, assessment of possible infiltration of sewage into soil, assessment of rate of pollutants penetration to an aquifer and changes in their chemical composition; assessment of pollutants dispersion, identification of main sources and causes of pollution, assessment of existing programmes on underground water monitoring; selection and realization of monitoring programmes, investigation of monitoring results, and data integration and transmission [181].

A somewhat different system of water quality monitoring has been established in Latin America. Here, the quality of potable water is observed much more thoroughly than other types of water investigated in general programmes aimed at the analysis of water resources. These programmes represent the surveys of the quality of water rather than monitoring. Observation of industrial sewage is practically absent. The development of systems of observation which are an integral part of regional projects on water resources management is the most successful [182].

In the USSR, a state-wide system is currently being set up for monitoring and evaluating long-range transmission of air pollutants. It will comprise seven monitoring stations sites in a close proximity to western borders in all main physicogeographic zones of the European part of the country. Along with the development of a monitoring system, considerable attention is being focused on the calculation of patterns intended for obtaining quantitative assessment of transborder streams as to concentration and fallout of atmospheric contaminants as well as for analysis and interpretation of measurement results [177].

The natural and anthropogenic changes in composition and properties of natural water bodies of the USSR are recorded by All-Union Services for Supervision and Monitoring of Pollution

of Environmental Objects. A hydrochemical network of this service conducts background observations on water bodies in the regions where pollutants could penetrate only after their global spread at the basic stations as well as at regional stations on water bodies where pollutants penetrate through regional migratory processes. Exhaustive information on background pollutants concentration, composition and properties of natural waters is offered by stations located in biosphere sanctuaries as well as in sanctuaries sites in typical rural areas [183].

When working with statistics as a basis for solving a variety of environmental problems, it is very important to keep cadastres of different kinds of land and mineral resources as well as to elaborate a unified cadastre (following the example of Bulgaria) which has adopted a law "On Unified Cadastres of People's Republic of Bulgaria", which embraces land and forest areas, inland waters, territorial waters of the Black Sea, including the continental shelf, air space over country's territory, etc. [184].

A special role in information collection and environmental statistics is assigned to air-space surveillance. The main tasks of this service are the search for remote-indicating means and elaboration of assessment techniques for a possibly broader range of environmental characteristics, working out recommendations and establishing air-space service for weather observation, and the development of technical basis and setting up of a system for rapid information transmission and machine processing.

Air-space information provides continuous space information on one or another component, the possibility of conjugate space assessment of various environmental components, the possibility of evaluation of a broader range of natural characteristics, equal effectiveness of remote-indicating techniques both in examined and non-examined areas, i. e. their independence of density of land-based regime service network and rapid information collection, transmission and processing [185].

The USSR has elaborated a programme of advanced research to last until 1990 which encompasses the following: working out methods for solving the most important problems of space and physical earth sciences, including investigation of current global geological and geographic forecasts; identification and prediction of ocean regions with high bioproductivity; study of the mechanism of hydrological régime of surface waters; dynamics of forest resources; monitoring of biosphere conditions and pollution; elaboration of air-space techniques for studying the condition of agricultural resources; determination of relationships of space-energy characteristics of radiation under the influence of external conditions and internal transformations of the objects under study; investigation of the radiation field of the Earth and determination of relationships between parameters, abnormalities and variations of this field and various geological and geophysical, natural and climatic processes taking place on the Earth and its interior, in the ocean and atmosphere; and improving methods and hardware for air-space information processing and subject interpretation [186].

In the United States, the National Environmental Satellite Service (NESS) is intended for processing images supplied from satellite systems operating in polar and geostationary orbits. These systems perform round-the-clock environmental monitoring and meet the needs of state and private users engaged in the field of earth and environmental sciences. Control complexes and subsystems for telemetry data receiving and processing, and information calibration, conversion and repro-

duction are incorporated in four NESS subdivisions: the satellite control centre; two stations for information control and collection; land-based and satellite communication networks; and centres for information processing, analysis and dissemination [187].

In recording environmental conditions, a growing role is assigned to UNEP's International Reference System for Sources of Environmental Information, INFOTERRA, incorporating ninety-six partner countries. It represents a decentralized system with activities based on co-operation among existing information services and systems at three levels: national centres (which co-ordinate information activities on environmental protection within an individual country); regional centres (which co-ordinate environmental protection measures in countries of a corresponding regional group); and sector centres (established by UNEP and involved in the investigation of international aspects of definite problems). The main working documents of INFOTERRA are national and international reference registers. At the beginning of 1979 the international register contained 7,100 sources from sixty-three countries on 1,000 various subjects. By the first half of the 1980s, the number of sources was expected to reach 20,000 and the number of partner countries — one hundred and twenty-five [188].

Three questions in the field of environmental information and statistics remain unanswered: what are the laws governing the formation of information, how information in the field of nature use differs from information in other fields of material production and how to overcome the objective onset of uncertainty.

It must be stressed that the scale and rate of analysis of problems do not meet the needs of science and practice. The benefits of the creation of an environmental information system are quite evident from the fact that existing economic damage often results from actions of experts, highly specialized in narrow fields, who fail to estimate the extent of environmental impact of their decisions as well as the economic consequences of that impact.

The science of statistics in the field of environmental protection is currently going through two stages, that of data accumulation and that of creating an information data bank.

Environmental statistics have three distinct features.

Interscientific character. The issues of ecologic-economic estimation of various industries cannot be solved without a thorough investigation of processes which are the subject of research for scientists of various branches of knowledge and for specialists of the numerous branches of economy. Therefore, the collection of initial data requires joint efforts on the part of appropriate scientists and specialists. For instance, the collection of information for evaluating losses due to deterioration of human health involves the combined efforts of doctors, physiologists, sociologists, meteorologists, physicists, chemists, economists, etc. The initial information obtained cannot be processed without mathematicians.

Heterogeneity. According to the reflected relationships between the objects, one could distinguish the following kinds of information: natural-science, technical, economic and socio-political.

Absence of specialized data collection. Since the environmental sciences are quite young, there is virtually no specialized data collection. There is nobody responsible for infomation collection, processing and storage as well as no information tables, questionnaires and forms of data collection. This entails the following: Decentralization. Since the damage is suffered by various branches of industry, informa-

tion collection is also necessary from establishments associated with the different branches. Nevertheless, even appropriate, competent departments of the branch are not able to collect all the information obtained on the subject. Pioneering nature of some information. Some portion of the information is fundamentally new, because it had previously never been collected. Therefore, for the time being one has to resort, to a certain extent, to subjective data collected through expert assessments and calculations. This calls for elaboration of a system for collection of new information. Influence of background factors. Since, along with environmental pollution, the functioning of biological and non-biological elements is also affected by a number of other factors, it is often difficult to determine the cause-and-effect relationships. This has to be taken into account when collecting information. To distinguish purely ecological relationships, it is often necessary to expand considerably the space or time realm of research. Thus, in order to single out these relationships in the process of information collection one must first select the region to be monitored, then investigate a variety of establishments at the same time and finally carry out research for a number of years. Information lag. Negative processes caused by environmental pollution do not occur immediately, but gradually. Such time lags also exist in the reverse process, namely, prevention of pollution effects. These properties should also be taken into consideration during data collecting. For instance, the measures for improvement of sanitary conditions of water bodies could yield results only after a period of time (often several years), when the enterprise will no longer be a polluter. Studies carried out within the same year as the implementation of sanitary measures takes place often result in wrong conclusions. Necessity of multistage collection. Environmental information cannot be fully collected in one cycle. Its specificity requires repeated return to the collection of certain data at a new level. For instance, following information collection and determination of the qualitative effect of the pollution level on the level of disease cases, exhaustive data collection in the determined narrower range is needed. Uncertainty of information. First, a distinction must be made between objective and subjective uncertainty. Objective uncertainty results from development and change of the ecologic-economic estimation of an industry. There are no doubts as to probability laws governing the development of different kinds of phenomena. Subjective uncertainty stems from a variety of interpretations and fallacy in determination of both the very notion of ecologic-economic estimation and the technique for its integration into a mechanism of evaluating the effectiveness. This uncertainty results from the absence of unified conceptual aid and underestimation of the importance of a terminological element. All this creates difficulties in understanding judgements based on disordered ideas established both within individual countries and when using imported information.

Environmental information can be divided into two types, primary and secondary. Primary information is obtained from direct observation, recording data and functional changes in the system resulting from the impact of pollution and other factors. Secondary information is derived by processing primary information.

The first stage of information collection should be familiarization with the specific character of the industry and its enterprises, aimed at the selection of the most typical polluters as objects for further studies and analysis. This stage is characterized by the collection of preli-

minary information on an enterprise: approximate range and volume of products, fuel used, basic production process, approximate composition and amount of discharged harmful substances.

The second stage is information collection for a qualitative analysis of the impact on man and the objects of his activity. This stage envisages identification of: pollutants producing harmful impact on man, farm crops and forests, municipal and industrial structure; processes taking place in investigated environmental components under the influence of pollution; indicators contributing to a qualitative assessment of these processes (what diseases are caused by pollution?, what farm crops and forests are affected by pollution?, what aspects of municipal economy and industry suffer from pollution?); and possible qualitative indicators of pollution impacts on various aspects of the economy.

The third stage of information collection is essential for objective assessment of economic measures, for adoption of appropriate environmental protection programmes and elaboration of planned tasks.

Statistical information forms a foun-
dation for state planning of environ-
mental protection measures. The state-
pianned system of environmental pro-
tection is carried out successfully in the
USSR. The main goal of the annual and
five-year plans on environmental pro-
tection and rational use of natural re-
sources is conservation and a streng-
thening of the natural raw material po-
tential of the country, quarantee of its
rational and complex use, abatement of
a negative impact of industrial and ag-
ricultural production as well as of ur-
ban municipal economies on the envi-
ronment, on reproduction of plant and
animal kingdoms and the creation of
the most favorable conditions for life,
work and recreation of population.

Determination of tasks in plans on environmental protection and rational use of natural resources in the USSR as a whole, in the Union Republics, ministries and government departments, autonomous republics, regions, areas and individual cities is aimed at recreating, reproducing and conserving water and land resources and plant and animal kingdoms, rational and complex use of mineral raw materials and protection of earth's interior, abatement of environmental pollution caused by waste of industry, construction, agriculture, transport, and municipal economy; improvement of environment in residential areas, at preservation in sanctuaries of the most valuable (from the scientific standpoint) natural complexes and at increasing the numbers of wild animals and rare plants by organizing a scientifically grounded network of reservations, sanctuaries, national parks as well as by implementing other environmental protection measures.

The regional nature of environmental changes resulting from intensive use of natural resources and pollution of atmospheric air, water bodies and soil with industrial and domestic wastes call for the elaboration of nature conservation measures in territorial and branch-related aspects of the plan.

For this purpose, when working out draft plans for nature conservation and rational use of natural resources, ministries and departments ensure the elaboration of these measures by subordinate industrial amalgamations, enterprises, agricultural, construction or other organizations and their co-ordination with corresponding local authorities or management in whose jurisdiction these entreprises and organizations are sited as well as with supervisory local services of the USSR State Committee on Hydrometeorology and Conservation of Nature, USSR Ministry of Water Management and Amelioration, Ministry of Agriculture, Committee for

Supervision of Safe Operation in Industry and Mining under the USSR Council of Ministers.

In preparing the proposals on development and location of branches of national economy, the USSR ministries and departments develop complex schemes of environmental protection for cities and large industrial centres, where the enterprises of a corresponding branch are the main users and polluters of the environment.

Along with the indicators approved in a State Plan of Economic and Social Development of the USSR in the chapter "Environmental Protection and Rational Use of Natural Resources", and with the specific characteristics of sectors of national economy taken into account, these plans envisage the implementation of measures directed at rational and complex use of natural resources, by-products (including production and consumption waste), secondary energy resources and material through developing and promoting new progressive technologies and creating closed water and/or gas recycling systems and waste-free production processes. These plans also provide for activities directed at the abatement and complete elimination of water, air and land pollution with toxic contaminants.

Planning water protection against pollution, contamination and exhaustion is carried out to preserve the country's water resources. With this aim in view, the five- and one-year plans must ensure: scientifically grounded water distribution among consumers, mindful in the first place, meeting of public needs in potable and domestic water; rational use of water resources, cutting down water consumption and losses of water during transportation and consumption; promotion of latest achievements of scientific and technological progress aimed at preventing the negative impact of economic activity on water bodies and securing their good condition both in qualitative and quantitative respects; preservation and improvement of biological productivity and recreational value of water resources; prevention of detrimental effect of waters on the environment; and appropriate technical condition and good order of water bodies.

The elaboration of a draft plan of rational use of natural resources takes into consideration indicators featuring the reduction of fresh water intake from the surface and underground sources by improving and promoting water-free production processes, by developing re-usable water systems, a shifting to air-cooled technical equipment, increased effectiveness of water consumption in irrigated agriculture, improvement of water supply systems, use of freshened, highly mineralized drain and mine waters as well as other similar measures according to specificity of each particular branch.

The following two indicators characterize rational water consumption at enterprises: ratio of the volume of drain water to the volume of fresh water consumption expressed in percentage and featuring the effectiveness of applied water supply system (except for the industries engaged in mining and processing of raw materials as well as enterprises and organization having water accompanying extracted or received raw materials); and multiplicity of water consumption determined as a ratio of gross water consumption to fresh water consumption.

To ensure protection of water against pollution, contamination and exhaustion, the draft five-year plans lay down the following tasks: discontinuance of discharge of polluted and contaminated sewage into rivers and other water bodies by promoting a progressive production technique preventing environmental pollution, complex processing of raw materials and utilization of industrial waste, reduction of pollutant concentra-

tion in discharged sewage to a level not exceeding the maximum permissible concentrations in a water body-sewage recipient; extraction of valuable substances from sewage; construction of effective (mostly urban) treatment facilities and other complex water protection systems.

It is envisaged that, by 1985, sewage discharge into the basins of major rivers and the Baikal Lake as well as into the basins of the Black, Azov, Baltic and Caspian Seas will be eliminated.

Similar tasks are planned for other water basins on the basis of the approved projects of complex use and protection of waters and territorial complex environmental protection projects as well as according to regulations issued by the bodies governing the use and protection of waters and by public health bodies, taking into consideration local conditions.

The process of planning the protection of water resources envisages economically sound promotion of closed circuit, drainless water supply systems, as well as repeated use of sewage treated to the established standards for technical water supply of industrial enterprises and in agriculture, for the production of fodder and industrial crops in irrigated lands.

The water protection measures also include tasks directed at preventing pollution of water areas by oil-containing ships as well as sewage and garbage discharged from ships. The appropriate enterprises and organizations establish indicators featuring the volume of ballast and bilge waters to be delivered to coastal treatment plants as well as equipping ships or other floating structures with special plants and devices for collecting oil-containing waters, ship's polluted domestic sewage, garbage and other harmful substances for delivery to coastal treatment garbage disposal plants, incinerators and waste processing and utilizing installations.

In addition to these measures, plans on the protection and rational use of water resources envisage such measures as planting water protection forest belts and other protection zones; discontinuing the pollution of water bodies caused by sewage from cattle breeding complexes and large farms and industrial and other agricultural centres; the prevention of penetration of mineral fertilizers and toxic chemicals from agricultural lands into water bodies, the prevention of pollution of water bodies during timber floating, including full halt of timber drift floating in major fishery waters and the clearing of floating routes from sunk timber; plans for waterside protection works and improvement and protection of water and other efforts on improving the technical condition and good order of common use water bodies.

Measures planned for air protection are aimed at maximizing abatement of toxic substances emitted into the atmosphere, with gases and aspiration air, from stationary installations arranged in enterprises of various sectors of the national economy and at all kinds of transport vehicles.

The measures providing for reduction of toxic substances contained in the surface atmospheric layer to the established norms are being worked out.

Activities aimed at abatement and complete ceasing of toxic emission into the atmosphere are planned on the basis of: projects on development and location of the productive forces; guidelines and plans for development of national economy sectors; volume of output and range of industrial products; complex system for the protection of urban air basins and territorial complex environmental protection projects; statistical data of hydrometeriological

[illegible] public health and departmental [illegible] as well as of bodies supervising the [illegible] and operation of scrubbing and dust-catching facilities and forecast of [illegible] condition of the air medium in the regions where subordinate enterprises and organizations are located.

[illegible]

[illegible] of conditions as well as the [illegible] of environmental impact of harm[illegible]

[illegible] plants, transition to [illegible]

[illegible]

organization of emission monitoring [illegible] and dust-catching facilities, the creation of a stock of high-quality [illegible]

[illegible]

[illegible] production processes and constructing waste-free industrial complexes.

The above-mentioned [illegible] should be implemented taking the following into account: the use of new kinds of energy resources and high-quality fuel, centralization and concentration of power plants to the optimum level from ecological standpoint, and increased use of secondary energy re[illegible]

[illegible] content, maximum utilization of [illegible]

[illegible] of the transfer o[illegible]

[illegible]

Peace and Detente Programme as a Basis for International Efforts on Environmental Problems

There is a direct relationship between poverty, hunger, disease, illiteracy, environmental pollution and the arms race. Growing military appropriations increase the number of persons who do not even have minimum norms of human society. There are some 1,200 thousand million illiterate men and women on the planet and 400 million children who do not have the opportunity to attend primary school: 2,000 million people live in shacks, mud huts or slums, without water, electricity or sewer. Every year, hundreds of millions of people die from diseases which could have been prevented, and which were wiped out long ago in richer countries. Some 800 to 900 million people live in poverty, never having enough to eat and barely keeping body and soul together. In 1978, 15 million children died before reaching the age of five.

Quoting these facts and figures, Lord Noel-Baker, participant in the special session of the Thirtieth Pugwash Conference (1980), underscored the fact that the arms race and poverty in the world constitute a double vice, two sides of a coin, closely connected with one another, and that armament and poverty are not two separate problems, but one common problem; the squandering of riches by man for warfare instead of improving life. People, he said, are begining to calculate how $ 500 billion could be used annually to eliminate hunger, ignorance, slums, were it possible to end the delusion which is forcing countries to compete in the accumulation of arms. The calculations are easy and simple, and the results are astounding: $ 200 billion for lowering income taxes, reviving the economy, raising living standards all over the world; $ 100 billion for capital investments in construction. Railroads, ports, harbours, power lines and demolishing structures which do not correspond to sanitary norms and which exist everywhere. There is a lot which can be done with this sum; the remaining $ 200 billion could be used to fight poverty.

Such a simple distribution of expenses could wipe out hunger and poverty as they are known today within a decade [189].

Everything mentioned above in a great measure, concerns international co-operation in the field of environmental protection, since, regardless of certain successes, progress is insignificant and is, without any doubt, being hindered by the arms race and by the reluctance of states to put an end to the militarization of their economies. A further exhaustion of natural resources is observed, primarily those of fuel and energy. The intensified arms race is expanding the scale and increasing the volume of environmental pollution, first and foremost radioactivity, which during the testing of any nuclear weapons can poison the environment to such an extent that future generation on the planet will be on the verge of annihilation without even a thermonuclear war being waged.

Methods of aggression directed at deteriorating the environment by artificially transforming the physical state of the natural factor, are nothing but organized ecological warfare. Regardless of the fact that scientific research in this direction still has an investigative trend, certain traits have been mapped out for practical implementation, in particular: stimulating the formation of low cloudiness and fog; in-

tensification of precipitation hindering the movement of military hardware; formation of electromagnetic fields in the atmosphere to hinder or distroy the existing types of troop communication; inducing the fallout of snow and hail, as well as earthquakes by underground nuclear explosions, which can lead to dislocation of geological structures activization of volcanic eruption; deliberate spread of bacteriological weapons which leads to the destruction of plants, animals and the enemy's army [190]. If we add to this the unpredictable, in a number of cases, character of such weapons in relation to all that is animate and inanimate on the Earth, then it becomes clear that the only alternative to solving environmental problems, in the broad sense of the word, is the joining of efforts of all lands and people in the struggle for disarmament and the further development of detente.

A continuous growth of military appropriations and the militarization of economies constitutes a direct threat of the breaking out of a number of local wars or of a universal nuclear missile catastrophe. Between 1945 and 1975 alone, there were 142 wars and military conflicts in the world. During these years, armed conflicts and wars broke out in the territory of 69 countries with 81 countries taking part.

International Environmental Protection. Goals and Tasks

The practical solution of complicated and diverse tasks of present-day environmental problems required the elaboration of a single international document on protection of natural resources, prepared by IUCN together with UNEP and WWF, with the consultative and financial aid of these organizations, and assistance from FAO and UNESCO. This document points out that the World Conservation Strategy is designed to stimulate a purposeful approach to biological resource management and to ensure an orientation policy for implementation of this approach.

The task of the World Conservation Strategy lies in achieving the following three goals in the field of biological resource conservation: to maintain major ecological processes and life-support systems (such as restoration and protection of soil, nutrient turnover and water purification) on which man and his development depend; to preserve genetic variety (the entire volume of genetic material contained in all living organisms on the Earth) on which the functioning of many above-mentioned processes and life-support systems depends, the implementation of the breeding programmes, necessary both for the protection and improvement of the varieties of cultivated plants, domestic animals, useful microorganisms, as well as the development of science and medicine, further technological process and supply of raw materials to many industrial branches using biological resources; and to ensure the optimal exploitation of biological species and ecosystems (especially fish and game animals, forests and pastures) which are the basis of existence for millions of rural inhabitants, as well as large industrial branches.

The reaching of these targets is urgent because (i) the ability of out planet to ensure the existence of man is diminishing both in industrialized and developing countries, billions of tons of soil are exhausted annually due to deforestation and low level of land use; and at least 3,000 square kilometers of agriculture land are used for construction of buildings and roads, (ii) hundreds of millions of rural inhabitants in developing countries, including 500 million undernourished and 800 million without means of existence, are forced to destroy the resources of animate nature in order to save themselves from

hunger and poverty; rural inhabitants cut down trees and shrubs for fuel in ever-greater radius around their villages; and rural inhabitants are annually forced to burn 400 million tons of manure and straw, which are necessary for restoration of soil fertility; (iii) energy, financial and other types of spending on goods production and services are growing; the drainage of water supply and hydro-power systems has been reduced by silting almost twofold in the world, especially in developing countries; and floods devastate settlements and spoil crops (in India, losses due to floods range from $ 140 to $ 750 million per year); and (iv) the raw material basis of important industrial decreases; tropical forests are cut down so rapidly that, by the end of this century, the area of productive forests, not under logging, will be reduced twofold; and litoral zones which serve as a basis for many fishing industries, are being either destroyed or polluted.

Six major obstacles facing preservation are: (i) the established view that the preservation of biological resources is only a limited sector, and not an all-embracing process which should be taken into account in all sectors; (ii) the resulting inability to connect the preservation of biological resources with development; (iii) the developing process, often rigid, brings unjustified damage to the environment, as a result of unskilful planning, irrational selection and distribution of natural resource use and an unjustified emphasis on short-term targets rather than more perspective and long-term ones; (iv) shortage or lack of possibilities and means for nature protection resulting from imperfect legislation, weak organization (in particular, at governmental establishments which do not have sufficient jurisdiction and coordinate badly their work), absence of trained personnel as well as the absence of a centre supplying information on the primary tasks, on the production and recovery potentials of biological resources and on potentially beneficial or harmful effects of this or that economic-management decision; (v) lack of concern for environmental protection as a result of ignorance (or very superficial notions) of the benefits provided by the preservation of biological resources and the responsibilities of those who use them or can affect them in some way, including governments; and (vi) the failure of attempts to ensure development bases on the preservation of biological resources where this is especially necessary, namely in the rural areas of developing countries.

That is why the World Conservation Strategy: defines the protection of biological resources and explains its aims and role in ensuring the survival of man and development, and the major obstacles on the way of these aims realization; determines the primary requirements for reaching every target; determines national and subnational strategies for solving primary tasks, specifying the framework and principles of this strategy; makes recommendations on perspective decisions in the field of environmental protection, on the interaction of different nature protection sectors and on broader systems of national financing to co-ordinate nature protection and the development at decision-making levels; proposes an integral methods of estimating surface and water resources together with an evaluation of the environmental conditions as a means of improving planning in this field, as well as outlines a procedure for the rational distribution of types of using surface and water resources; recommends a review of legislation on the protection of biological resources, proposes general principles of organizational activities within the framework of governments, and in particular proposes ways of improving the

organizational possibilities for preserving the soil and biological sea resources; proposes ways to increase the number of qualified personnel as well as to conduct research, more oriented towards management, and management more oriented towards research, to immediately provide required data; recommends a broader participation in planning and decision-making conserning the use of biological resources and proposes programmes and campaigns on education and the dissemination of knowledge concerning the preservation of biological resources; and proposes ways of rendering assistance to rural communities for preserving local biological resources as a basis of their development.

In addition, the strategy recommends international action for promoting, supporting and (when the need arises) co-ordinating national undertaking, placing special emphasis on the need: for a more strict and all-embracing international legislation on nature protection, and more aid to development with the aim of preserving biological resources; for international programmes on preserving tropical forests and arid lands, protecting the regions necessary for preserving genetic resources, and preserving common property of mankind; and for different types of regional strategies aimed at preserving joint biological resources, particularly international rivers and seas. Finally, the World Conservation Strategy sums up the major requirements necessary for a stable development, determining the primary tasks for nature protection in the third development decade [191].

Thus, every stage in the development of a socio-economic formation has specific laws of interaction with nature. While in previous epochs, the interaction was based on adaptative functions to the environment and, mainly influenced local ecosystems, at the present stage of scientific and technological progress the condition of the environment completely depends on its world-wide strategy of life support and impact on nature. Man has become a planetary phenomenon and a great transformer of the world.

The extension of regional and interregional activity by UNEP is important in this respect. It involves the creation of GEMS, the International Referral System (IRS), the International Register of Potentially Toxic Substances, the realization of the Plan of Action to demonstrate ecologically appropriate forms of schistosomiasis, malaria and cotton pest control; the creation of a global system of microbiological resources centres; the development of a global plan for regeneration, protection and rational use of living resources, organization of a network of parks and other protected areas, and elaboration of recommendations on ecologically sound lines of development, including rational use of natural resources at national and international levels; the establishment of a global system of research institutions for experimentation, verification and practical application of ecologically appropriate technology; ensuring a wide adoption and use of conventions and protocols, already existing and under elaboration, on environmental protection; co-ordination of principles for states to follow in their interrelations in the field of common natural resources, as well as problems of responsibility and compensation for environmental pollution and resulting damage.

With this purpose in view and in compliance with decisions of the eighth session of the Governing Counsil of UNEP (for the period of 1984-1989), aided by subject-programming and together with other United Nations bodies, the System-Wide Medium Term Environment Programme (SWMTEP) is in action. It will be revised every second year [192].

Bilateral and Multilateral Co-operation in Protection and Rational Use of Natural Resources

The scale of intergovernmental co-operation in ensuring the rational use of natural resources is constantly expanding. This can be well seen from the examples of CMEA, EEC and OECD.

CMEA member-countries first began multilateral co-operation in the field of protecting and rational use of natural resources in 1964 during the process of elaborating a joint co-ordination plan for important scientific and technological research with included the 'Protection of Water and Air Basins from Harmful Substance Pollution'. This problem contained seven topics, four of which were co-ordinated within the framework of the Conference of heads of water management departments of CMEA members, and the other within the framework of the CMEA Standing Commission on Co-ordinating Scientific and Technical Research which, in 1971, became the CMEA Committee for Scientific and Technological Co-operation.

During 1964-1971, 100 important works were completed, among which special attention should be given to Single Criteria and Norms of Surface Water Purity and Principles of Their Classification', 'Unified Methods of Planning Measures for Water Purity Protection', 'Stages of Establishing Enlarged Norms of Water Consumption and Quantity of Sewager per Unit of Production for Various Industrial Branches'. Reports disseminated included: 'On Unification of Methods and Technical Means for Studying the Quality of Waters', 'On Methods of Sewage Treatment and Processing', 'On Protecting Surface and Underground Waters from Pollution with Phenols, Oil Products, Flotation Reagents, Synthetic Detergents and Other Pollutants', and 'On Methods of Treating and Processing Sewage of Various Industries'.

In 1972, in accordance with the comprehensive programme of socialist economic integration, the Council for the Protection and Improvement of the Environment organized under the auspices of the CMEA Committee for Scientific and Technological Co-operation, prepared a larde-scale programme of co-operation for CMEA member-countries and Yugoslavia for the period up to 1980, approved by the Executive Committee of CMEA in 1974, concentrating on the socio-economic, organizational, legal and pedagogical aspects of environmental protection; hygienic aspects of environmental protection; protection of ecosystems and landscapes; protection of the atmosphere from harmful substance pollution; meteorological aspects of atmospheric pollution, noise and vibration control; water protection from pollution; neutralization and utilization of domestic, industrial, agricultural and other wastes; radiation safety; main lines in urban and suburban planning as well as in systems of population setting with due regard for the protection and improvement of the environment in CMEA member-countries; protection of deposits and rational exploitation of natural resources, and the global system of environmental monitoring.

Among the investigations in this field, special attention should be given to such topics as: 'Elaboration of Methods for Evaluating Economic and Non-economic Influence of Man on the Environment', 'Ecological Basis of Planing and Development of Optimal Landscape Structure' and 'Elaboration of a Scientific Basis of a State Cadastre of Natural Resources'.

Research carried out in the 'model' regions of CMEA member-countries has considerable significance for the elaboration of a single strategy for the ra-

tional use of nature. Since 1975, such research has been conducted in Czechoslovakia model region of Ostrava (area 3.9 thousand square kilometres, population 1.1 million, population density 281 per square kilometre, and industrial personnel numbering 230 thousand). Some 85 per cent of the country's coal output is concentrated in this large industrial centre, as well as leading metallurgical enterprises.

Similar investigations have been carried out in the Varna-Devna model region (Bulgaria) since 1977. The Devna chemical complex accounts for 100 per cent of the Bulgarian output of soda ash and sodium hydroxide, 45 per cent of phosphorus fertilizer, 40 per cent of sulphuric acid, and 23 per cent of cement; Varna is a large tourist centre.

In the USSR, such research was begun in 1978 in the model region of Kursk (area 29.8 thousand square kilometres, population 1.5 million). Some 10 million tons of iron ore with an average iron content of 58 per cent and 15 million tons of low-grade (36 per cent) are extracted in the region. The first block of a 1 million kilowatt capacity of the Kursk atomic power station was put into operation in the town of Kurchatov in 1977.

The model region of Bitterfeld (German Democratic Republic) where investigations have been carried out since 1979 covers an area of some 3 thousand square kilometres with a population of 650 thousand. Other model regions include Tatabanya (Hungary), Cele-Koper (Yugoslavia) and Suwalki (Poland) [193].

Over 540 research and designing organizations from CMEA member-countries participated in the fulfilment of the General Programme of Co-operation Between CMEA Member-Countries and Yugoslavia on Problems of Environmental Protection and Rational Use of Natural Resources. The co-operation was conducted within the framework of 17 CMEA standing branch commissions and 10 councils dealing with separate problems. By the middle of 1978, over 1,200 research projects had been completed, of which some 400 found practical application in the economies of CMEA member-countries [194].

The new programme was planned to consist of the following two sections: (1) problems of interbranch fundamental character and general problems; and (2) problems of interest to various branches and types of production. These sections correspond to the decision of the thirty-first CMEA session to pay special attention to the solution of problems related to economic tasks of long-term programmes based on applying the results of the multilateral economic co-operation to the national economies.

International co-operation in environmental protection also underwent notable changes within EEC. For a long time, the joint activities of EEC member-countries involved essentially traditional information on nature protection and the need to set up different reserve zones. At the beginning of the 1970s, EEC adopted a number of declarations and recommendations, including the Water Resources Charter (1968), the Declaration on Principles of Air Pollution Control (1968) and the European Declaration on Nature Protection (1970).

EEC countries began a broader co-operation in 1973, after the adoption of a joint environmental programme, which, among other elements, envisaged the following major projects: evaluation of the effects of pollutants on human health and on nature; introduction of sanitary norms for pollutant concentration in the environment and for substances and items to which man is exposed; development of environment monitoring; measures for lowering the emission of pollutants in cer-

tain industries; prevention of sea pollution; problems of collection, trasportation and recovery of production waste and consumption; converging of legislation of the member-countries on individual aspects of environmental problems; economic aspects of preventing environmental pollution; development of scientific research; exchange of information concerning nature protection; rational use of natural resources and problems of life environment and production environment [195].

The economic crisis in 1974-1975 made it impossible to carry out most of the cited projects, which resulted in the adoption of the second EEC environmental programme in 1976 for the period 1977-1981. In essence, this programme was the continuation of former activities and envisaged the complection of the work begun on determining criteria for the quality of water and air, the elaboration of single norms for dischanging harmful substances into coastal waters and the establishment of single maximum permissible concentration of harmful substances in motor transport exhausts. It was also envisaged to work out a joint long-term programme for building water treatment facilities and setting up a network of pollution monitoring stations.

For the 1980s, EEC policy in environmental protection envisages: establishment of environmental quality standards; solution of transport pollution problems through international co-operation; transition to a qualitatively new stage of natural resources management based on overcoming the conflict between economic growth and environmental purity; and broadening public knowledge on environmental problems [196].

The following major measures have been carried out within the framework of EEC environmental programme: draft directives on the quality of water used to satisfy the need of the population (1975); draft directives on the quality of water in oyster and crab beds (1976); directives on discharging harmful substances into waters (1976); draft resolution on establishing criteria for sulphur dioxide content in the atmosphere of cities (1976); directives on toxic and harmful waste during collection, transportation, purification, storage and discharge (1978); draft directives on the protection of underground waters against pollution; directives on the protection and improvement of the quality of fresh water in pools used for spawning and fattening of valuable food fish species (1978); directives on the content of lead and oil which established the maximum content of lead in commercial oil at the level of 0.4 gramme/litre (1978); and proposals for drawing up directives on controlling the noise produced by compressors and on elaboration methods to estimate expenses for industrial pollution control.

Attempts were made to standardize national policies in the environmental field in conformity with OECD proposals. But the differences of the participating countries on fundamental issues of ecological standardization, which clash with economic and financial interests of firms and corporations, create insuperable difficulties for the solution of complicated environmental problems. Thus, although most OECD countries recognize the urgency of the proposals and the need for stepping up environmental protection measures, they show great restraint in pursuing the environmental protection policy and in the solution of problems dealing with modernization of production techniques at industrial enterprises, changing the structure of production and consumption.

Another European organization conducting international co-operation on environmental problems is the Nordic Council which includes Norway, Sweden, Denmark, Iceland and Finland.

The corresponding programme of the Council and the Convention on joint measures envisage efforts on reducing the pollution of the Baltic Sea, eliminating solid waste, lowering the noise level industries and transport and conducting the necessary scientific research, exchange of information, nature protection and recreational use of landscape.

But, regardless of the activation of efforts in the field of multilateral co-operation on protection and rational use of natural resources, the efficiency of this action is still quite low. Together with the arms race and militarization of economics, one of the reasons holding back the results of joint work is the lack of unity in action of many international organizations. The unification on their joint efforts would make it possible to raise the efficiency of international co-operation in solving environmental problems not only on the European continent but throughout the world. This view was shared by EEC in its second ecological programme (1976-1981) which, among other things, points out that an all-embracing policy in the environment field is possible only on the basis of new, more effective forms of international co-operation which take into account the existing ecological situation on a world scale [197].

An example of bilateral co-operation on complex environmental protection problems is the agreement signed by the USSR and the United States in 1972. The most significant results of this co-operation were reached in the field of water protection. An exchange was completed of scientific information on a complex study of the Seversky Donets (USSR) and Connecticut (United States) river basins. A Soviet-American symposium 'Methods and Practices of Planning for River Basins Protection' was prepared. Positive results were also attained by joint investigations on modelling and methods for improving water quality. The Great Lakes (United States), the southern part of Lake Baikal and regions of the Sea of Azov (USSR) were used for the analysis of complex problems of lakes and estuaries. First, the problem of water dynamics and the spread of pollutants were investigated. The exchange of specialists resulted in a notable progress in mathematical modelling of water ecosystems and in the elaboration of methods of water quality control and monitoring, including automatic control systems.

American scientists devote considerable attention to working out water quality criteria for water biota, first and foremost fish. A wide range of toxic substances and their accumulation in the fish organisms is studied. Under elaboration are biological indicators of industrial and urban sewage toxicity. In industry, special attention is given to chemical treatment of sewage, wood-pulp and paper enterprises and oil refineries in particular [198].

Along the lines of environmental hygiene, the USSR and the United States have carried out the following basic projects: development of methods for the quantitative estimation of biological effects produced by chemical agents in the environment (action of benzol, sulphur dioxide and nitrogen dioxide, as well as biological effects of various levels of mineralization of desalinated potable water); elaboration of methods for predicting biological effects caused by chemical agents available in the environment (the impact of ozone, nitrogen dioxide, chlorinated carbohydrates, organic phosphates, toxic effects of certain elements — cadmium, aluminium, boron, as well as the biological action of benzene derivatives); study of biological effects of chemical agents of long-term action (action of benzapyrene, teratogenic and em-

bryotoxic effects of pesticides and other chemical substances, the role of CS_2, carbon monoxide, cadmium and lead microconcentrations in the development of changes in the cardiovascular system, carcinogenic effects of nitrosamines available in foodstuffs due to application of nitrogenous fertilizer, as well as those resulting from conversion of nitrates used as preservatives); study of biological impact of physical factors of the environment (analysis of microwave irradiation at various frequencies and under different conditions, static and low-frequency electromagnetic fields).

Similar agreements envisaging bilateral co-operation have been signed between the USSR and Belgium, Bulgaria, Finland, the United Kingdom and other countries. Multilateral agreements envisage the protection of certain types of natural resources as well as flora and fauna.

International Environmental Legislation

Regardless of the fact that there are over 300 international agreements on various aspects of environmental protection, this aspects of international law is still at the development stage. The difficulty of elaborating unified juridical norms in this case lies in the interdisciplinary character of international agricultural, marine, air, water, sanitary and financial laws which many states interpret in different ways.

As a special aspect of international law, environmental protection should be based on the following major principles.

Beyond state boundaries, the environment is the property of all mankind. This means that natural resources which lie outside national jurisdiction as well as 'no man's' space, are common property of all countries and peoples and should not be occupied or seized in any form.

Freedom of investigation and use of the environment and its components. All states and certain international and intergovernmental organization beyond the limits of national jurisdiction should have the right, without any discrimination whatsoever, to conduct lawful activity in the environment.

Rational use of the environment. All states are fully responsible for the protection of 'no man's space', the exploitation of which should be carried out effectively and at a maximum stable level; prohibition of national appropriation of the environment or its elements.

Beyond national frontiers, nations should not emit into the environment toxic or other substances.

International co-operation in investigating and exploiting the word's environment should be promoted. Joint action of large and small countries on the basis of equal and mutally beneficial conditions for the organization of effective monitoring, for preventing, reducing and limiting the negative impact on the environment and natural resources is vital [199].

Norms of international legislation on environmental protection have to a considerable extent been worked out for space, atmosphere, oceans, international rivers and several elements of the animal kingdom. Some of the most important international legislative acts on environmental protection are listed below:

International Convention on Protection of Birds Useful for Agriculture (1902);

Protocol for the Prohibition of the Use in War Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (1925);

Convention on the Preservation of Flora and Fauna in Their Natural State (1936);

Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (1942);

International Convention for the North-West Atlantic Fisheries (1949), revised in 1977;

Interim Convention on the Conservation of North Pacific Fur Seals (1957);

Convention on the Continental Shelf (1958);

Convention on the High Seas (1958);

International Convention on Plant Protection (1950);

International Whaling Convention (1946);

International Convention of Bird Protection (1950);

Convention on Civil Liability for the Sea Transportation of Nuclear Materials (1971);

Convention for the Conservation of the Antarctic Seals (1972);

Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973);

International Convention for the Prevention of Pollution from Ships (1973);

Convention on Fisheries and Protection of Animate Resources in the Baltic Sea (1973);

Convention on the Protection of the Marine Environment of the Baltic Sea Area (1974);

Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (1977);

Agreement on Conservation of Polar Bears (1976);

Convention on Civil Liability for Oil Pollution Damages Resulting from Prospecting and Exploitation of Mineral Resources of the Sea Bed (1977).

In all, by the end of 1977, there were some eighty multilateral international acts registered in international conventions and protocols of UNEP aimed at preventing sea pollution with oil, radioactive and other harmful substances; rational use of fish resources and other sea animals; conservation of the plant kingdom and certain species of terrestrial fauna, as well as whole nature complexes [131]. The need for joint international action in environmental protection is also reflected in the Final Act of the Conference on Security and Co-operation (1975), as well as in the materials of the All-European Summit Conference on Co-operation in the Field of Environmental Protection (1979).

In various international environmental surveys, attention is drawn to the poor quality of potable water, intensification of water eutrophication, air pollution and pollution with toxicants harmful to human health.

According to UNEP's state of the Environmental Report, in 1979, there were 200 million sufferers from schistosomiasis as a result of a wide-scale construction of dams and irrigation systems, and almost 600 million potential sufferers in seventy-two countries [200].

Another serious threat to human health is anthropod pests, of which there are now more than 360 species. According to WHO and UNEP, 223 species of agricultural pests, including the Colorado beetle, rice carpenter moth and ball weevil have notably raised their resistance, and in a number of cases have stopped responding to the most effective pesticides. FAO has confirmed that seven species of rodents, including the most distributed Norway and black rats, have developed an immunity to toxic chemicals.

The weed situation is somewhat better as they do not inherit an immunity to chemicals. Medical workers are anxious about the failure of agricultural chemicals to affect 121 species of insects. In 1969, there were fifteen species of malaria mosquitos which did

not respond to DDT, and thirty-seven species to dildrin; in 1976, their numbers rose to twenty-four and forty-three, respectively. A higher immunity of the malaria mosquito has been established in sixty-two countries, whose population suffers from malaria [201].

Specialists have estimated that, with the maintenance of today's standard of living, a growth of GNP of only 3 to 4 per cent and absence of further scientific and technical progress in the development of ecological technology, the level of environmental pollution in 1985 can increase by 20 to 30 per cent. But while the growth of industrial discharge pollution is expected to be only 10 per cent, in agriculture it will increase by 50 per cent, as a result of the annual 4 to 6 per cent increase in pesticide and fertilizer application [202].

In certain countries, environmental pollution is many times higher than maximum permissible concentrations. The amount of sulphur in lakes of Scandinavian countries is [illegible]. The Ruhr basin is strongly polluted, as well as certain industrial centres of Japan, Poland, USSR, the United Kingdom and the United States. The Danube, flowing through eight countries and collecting water from territories of eleven, is in need of conservation. Especially [illegible] is the intercontinental pollution of the [illegible] resulting from nuclear [illegible] [illegible].

At the Fourth IUCN General Assembly (Ashkhabad, USSR, 1978) [illegible] people in sixty countries. This could result, by the year of 2000 in one third of agricultural land being unfertile [3]. It must not be forgotten that 25,000 plant species and some 1,000 animal species are on the verge of extinction.

These problems can be seen clearly against a background of chronical malnutrition, insanitary conditions, spread of infectious diseases and all other concomitants of destitution and poverty which have involved the densely populated regions. The elimination of the plagues of the 20th century in many respects is predetermined by socio-economic conditions of people and to a great extent depends on their social structure.

UNESCO Views on Environmental Problems

In its Second Medium-Term Plan (1984-1989) UNESCO analyzes the world problems and discusses the environment and natural resources, saying that:

There is another area in which complex networks of interactions now appear to bind the fate of the individual inextricably to the collective future of mankind: this is the relationship between man and nature, which provides the resources essential to his life and activities and the irreplaceable setting for his existence as one among other living beings.

In this regard, there was for a long time a tendency to concentrate attention on the influence of the environment on the development of human societies, on their pattern of organization and lifestyle and on the various forms of habitat, and also on individual perceptions and behaviour in respect of environmental conditions.

Attention is now also focused, as the result of a new awareness which has become especially marked over recent decades, on the pressure that

man's activities, based on technological advance, exert on the environment, either through the unchecked eating-up of resources and of space, or through the production of wastes that the natural environment can no longer absorb without suffering far-reaching effects. The major risks emerging in the relationship between man and nature are the exhaustion or scarcity of certain non-renewable resources essential for human activities and irreversible damage that might jeopardize the balance of the biosphere.

In recent years, many studies have been made of the technical and quantitative aspects of the problems; these studies, which have in certain cases made a major impact, have aimed, among other things, to predict future trends in the consumption of mineral resources, often by extrapolating current trends; they have also tried to evaluate available resources, whether proven or probable, whether they could be exploited with current technologies or required new ones, and whether their use would be economically viable under present or only under vastly different circumstances. The problems are bound up with several sets of parameters which in [illegible] dependent on [illegible] of resources [illegible] from the [illegible] the Earth [illegible] emphasis should [illegible] lue of remote [illegible] facilitate geological [illegible] account of all these [illegible] by any seri[illegible] diate future.

But in the particular case of energy resources, given their [illegible] importance and the fact that consumption is set to go on rising in the coming decades, the prospect of oil and gas resources dwindling over a period that is difficult to measure but can be estimated in terms of decades rather than centuries means that thought must be given in the medium term to the problem of the transition to other sources of energy, the transition from the present economy, heavily reliant on the combustion of hydrocarbons, to one based on more diversified sources, above all renewable ones. In the long term, i. e. after the early decades of the twenty-first century, a massive input of renewable and virtually inexhaustible [illegible] and solar energy may be foreseen

In the medium term, then, the objective must be to manage the transition in a controlled and ecologically acceptable way and, to that end, to solve the [illegible] the economic and social changes that become necessary. Action should concen[illegible] cularly in the industrialized countries, so as to avoid waste — this will requi[illegible] of processes consuming less energy [illegible] the development of such energy sources as coal and nuclear fission (al[illegible] with the risk of accidents and with the storing of highly radioactive waste), [illegible] suitable for countries with less centralized distribution systems and grids [illegible] tric stations, peat-fired thermal stations, [illegible] tors, biogas fermenters, etc.).

As for the state of terrestrial resources and [illegible] environment, [illegible]

te some signs of improvement in such matters as atmospheric pollution in certain major conurbations, there are considerable grounds for concern. Large areas are threatened by desertification, erosion and soil salination; the area of the land where yields are drastically reduced by desertification in any given year is estimated at a minimum of 6,000,000 hectares.

This situation contributes to the aggravation of the food problems affecting the greater part of mankind, while population pressure is giving rise to growing needs. Agricultural output must grow on a worldwide scale to meet the foodstuff needs of over 4,000 million human beings, whose numbers will exceed 6,000 million by the end of the century. This growth can only be achieved through the cultivation of unused lands, more irrigation and, above all, increased yields. But resources must be rationally managed if what is being done is not to be compromised or even brought to nothing by soil deterioration.

Furthermore, deforestation is proceeding apace, particularly in the tropical forests which are dwindling by some 10,000,000 hectares a year as a combined result of clearances to make more lands available for cultivation and felling to provide firewood and timber for export. Serious consequences may ensure from the disappearance of plant and animal species, which impoverishes the genetic heritage of the planet, and also from an often irreversible deterioration of the soil.

A further vitally important matter is that of water resources. Although these are still abundant, a very large number of people are still deprived of drinking water: in 1980, only 29 per cent of the rural population had access to water of satisfactory quality, and sewerage was provided for only 13 per cent. In the urban agglomerations, the percentages were 75 and 56 respectively. The scarcity of water resources that is making itself felt in many regions, often combined with the irrational use of those still available, hinders economic development and social progress. Despite what has been done in pollution control, rivers and lakes are still threatened with pollution by industrial and even agricultural activities.

Concern over climatic change is equally great. Although it is difficult, not to say impossible, to make assertions about clear overall trends, the recurrence of periods of exceptional drought in several regions of the world is a striking fact. Moreover, the increased concentrations of carbon dioxide and chlorofluorocarbons in the atmosphere, and of nitrogen and sulphur compounds in the troposphere, have effects ranging from changes in the ecoclimate, the water cycle and ecological balance to more serious disturbances in the macroclimate. In this respect, emphasis should be placed on the role that tropical forests can play in the general purification of the atmosphere. The gradual dwindling of these forests could thus have a serious impact on the quality of the air that circulates around the Earth.

Human activities connected with the ocean seem bound to increase considerably in the coming decades. Historians and geographers have, admittedly, long emphasized the importance of the sea, particularly in the development of certain civilizations, its role in the regulation of the climate and the potential that it holds out for human life; but since man has been able to look down on the Earth from space, the idea that it is in fact the planet 'Sea' has taken on a concrete, intuitive reality. Two thirds of the planet's surface lie beneath the oceans and the seas, but are still inadequately explored despite their traditional economic importance and the research carried out in recent decades. The extent to which the riches

of the oceans are now coming to be used is making the problems of the conservation of fishery resources and the protection of the marine environment over increasingly large areas more acute. A new type of relationship between human societies and the oceans is in fact coming into being. The mineral and energy resources of the continental shelves are being more widely exploited; the investigation and use of the mineral resources of the ocean beds, regarded as the 'common heritage of mankind', hold out much promise and represent a challenge to the technology of the future. Men are learning to work under water and to control the development of the living resources of the sea, as in the case of agriculture — a process reminiscent of that which, tens of thousands of years ago, led to the domestication of animals and the development of agriculture.

In all the areas to which reference has just been made, the role of scientific research as a source of knowledge and a basis for the rational management of resources is essential. In the present decade, scientific research more particularly in the context of international co-operation must be directed to studying the regenerative and renewal capacities within ecosystems, continuing the survey of resources, assessing the consequences of the ways in which they are being used, examining the forms of land occupancy and systematically exploring areas like that of the seas, of which we still know too little.

But our thinking about the environment, the setting of man's life, cannot overlook the problems raised by population trends. Between 1950 and 1975, the world population increased from 2,500 million to 4,000 million, a growth unprecedented in the history of mankind. It is now estimated at 4,600 million and by the year 2000 will probably have reached between 5,800 and 6,600 million. The growth rate will, it is true, vary from one region of the world to another. The increase in the population will be much greater in what are at present the developing countries, whose share in the world population will rise considerably, while that of the industrialized countries will decrease. It can in fact be expected that, in the year 2000, the developing countries will reach a total of between 4,500 and 5,200 million inhabitants according to the different projections (as against 2,800 million in 1975) and the industrialized countries a total of between 1,300 and 1,400 million (as against 1,100 million in 1975). The age structure of the various populations will also develop in very different ways: an increasing proportion of young people in the developing countries, ageing of the population in most of the industrialized countries. In any event, the double objective — meeting the needs of a growing population with a new age structure and with all the attendant consequences, and turning to account the potential which it will represent — will be of major importance in the coming decades.

These concerns must be seen in the context of questions of society and development which are of decisive importance as regards the environment. Underlying all these problems, in fact, are the forms of production and consumption of the industrialized countries. In [illegible] ment and natural resources are treated [illegible] high short-term returns, and the cost of environmental damage is overlooked. Society as a whole, considered either nationally or internationally, then has to bear costs which are entirely neglected in any economic reckoning. This type of behaviour, which leads to unrestrained and what might fairly be termed

unscrupulous exploitation of natural resources, gives rise to serious damage. In many Third World countries, it entails an overworking of natural resources that is detrimental in the long term, whether they be living resources, like forests and fish stocks, or mineral resources occurring in finite quantities.

But situations of underdevelopment, in themselves, also have unfortunate implications for the environment. Poverty leads to over-use or irrational use of the productive capacities of ecosystems, of soil, water and wood. It also leads to uncontrolled extension of urbanization, which has today become a major problem in many countries.

Urbanization in the industrialized countries has involved considerable economic and social costs in terms of congested infrastructures, transport difficulties, air pollution and noise, it has produced slum areas, on the outskirts or, in some cases, in the very centre of cities, where people, often belonging to ethnic or linguistic minorities, experience serious problems in fitting into social and cultural life. Current urbanization in the Third World is maked chiefly by its rapidity and scale; it is accelerated, in a situation of high population growth, by the movement towards the towns of rural populations impelled by necessity — food shortages, famine and sometimes the collapse of traditional production systems — and by the often illusory hope of a better life. Huge settlements thus come into being where millions of people live in dire poverty. The evils from which these areas suffer are known to all, including as they do insanitary housing, wretched shanty towns, heaps of rubbish, shortage of drinking water and lack of recreation facilities. The people themselves are very largely unemployed, and such phenomena as prostitution and delinquency take root among them all too easily.

For the first time in history, the Third World has now outstripped the industrialized countries in terms of the number of cities with over a million inhabitants. According to United Nations estimates, this number will double before the end of the century. This growing rate of urbanization calls for bold physical planning policies which should be aimed at improving living conditions in rural areas by freeing populations from the many limitations affecting them, by improving the productivity of labour, particularly in agriculture, by giving people greater facilities for access to education and providing more job opportunities locally. They should also enable the necessary structures to be established in urban areas to help newly displaced people adapt themselves to a radically different environment and life-style and find opportunities for social advancement.

Environmental problems can never be considered apart from the present forms of the international division of labour and the constraints imposed by the international economic system. Control by the developing countries over their own natural resources is, incidentally one of the main lines of emphasis in efforts to bring about a new international economic order. It therefore seems particularly important that the developing countries should be able to acquire and build up means of surveying their resources and of providing initial and further training for their own specialists, so that they may be able to choose the best ways of using those resources to meet the needs of their people and to increase their capacity for progress, without jeopardizing the balances of the biosphere.

This objective cannot be dissociated from the idea of a global environmental ethic based on wise use of the resources that the planet offers to men and human ingenuity succeeds in discovering and turning to account.

Such an aim may in the long term imply changes in the manner in which resources are used in most countries of the world, eventually involving far-reaching changes in behaviour and recognition of the primacy of such values as solidarity and equity in application not merely to people alive today but to those who will come after us, as opposed to behaviour guided solely by immediate self-interest.

"...The contribution which public education and information may make to the formulation and application of solutions to the problems presented by the environment and use of natural resources is all the more significant in that these problems are largely of man's own making.

Education may create widespread awareness of the relations between man and the environment on which he depends, as well as of the difficulties that exist, their seriousness, their causes and effects, and of suitable measures to overcome them. Environmental education is an important component of education and deserves to be given a place in curricula at all levels and in all types of education, with the twofold aim of fostering a more precise understanding of the problems and of arousing a desire for active participation in measures to solve them. Such education cannot be purely cognitive, it should also develop appreciation of and respect for the environment, together with a sense of responsibility and a concern to contribute, through the adoption of suitable behaviour in everyday life or at work, to the protection and improvement of the human environment.

While it is essential that specialized personnel be trained in the various branches of environmental sciences, it is just as important that environmental education be provided for those who, without being specialists, are nevertheless called upon to take decisions or to engage in action having significant effects on the environment, which is the case, in particular, of administrators, economists, engineers and town planners, but also of other socio-occupational categories, such as technicians, supervisory staff and skilled workers. One of the responsibilities of establishments of higher education and scientific institutions is in any case to help in adapting the types of training given and using the findings of the research in which they are engaged for educational purposes.

The development of educational action comes up against obstacles which derive from the lack of liaison between the production of knowledge and its utilization in education and from imperfect curriculum design, the inadequacy of curriculum content or lack of preparation of educators for this new role. These obstacles also include the over-abstract character of education and the fact that it is not fully adapted to the environment and inadequately oriented towards the understanding and solution of the problems of society. The mode of organization of studies and curricula, arranged essentially by discipline, is not conducive to elucidate such complex problems.

These considerations also apply to public information, all too often fragmentary or unbalanced, wavering between the obscuring of problems or, on the contrary, their dramatization. In view of the decisive role of the communication media in determining public perception of changes in the human environment and its quality, as well as modifying behaviour patterns, accurate, balanced and regular information is of capital importance.

Efforts will be made to encourage the utilization of the findings of interdisciplinary research in environmental protection and management in general education and for public information, the selection of measures to introduce and extend environmental education in all types and at all levels of education and the training and development of school curricula and non-formal activities in the environmental education."

CONCLUSION

Under present-day conditions of the development of mankind every citizen has the right to receive environmental education so that in his practical activity he can successfully promote the creation of socio-economic, political and ecological relationships between society and nature, promote the strengthening of peace, the further relaxation of international detente and understanding among states. The realization of this right, especially in the developing countries where the overwhelming majority of the population of the planet live, is connected with great difficulties.

Among numerous factors hindering the dissemination of knowledge on the ties between the quality of the environment and living standards, stand out such factors as inadequate satisfaction of major material needs, including chronical malnutrition, lack of elementary housing and sanitary conditions; spontaneous development of general culture, low level of literacy; poor organization of production and management; shortage of high-qualified teachers, special literature, curricula and programs.

The success of environmental policy to a great extent depends on breaking down notions long-established in people's minds on the limitlessness of natural resources and potentialities of the biosphere. This is connected with a deep and lengthy process of fundamental transformation of the entire system of education which has embarked upon a qualitatively new stage of its development.

Taking into account the important role of instruction, the Intergovernmental Conference on Environmental Education (Tbilisi, 1977), organized by UNESCO in co-operation with the United Nations Environmental Programme (UNEP) worked out unified goals, criteria and aims of an interdisciplinary approach to teaching various social, economic and physical aspects of the environment, taking into account local, national, regional, subregional and international points of view. A complex character of environmental education is of great importance.

The present-day realization of the guiding principles of the Tbilisi Conference, fostering of a careful and thoughtful attitude to the environment, extension of knowledge and skills necessary for protection are possible only with the availability of educational and methodological literature and teaching aids. This sourcebook is prepared for a successful fulfilment of these tasks. It will help teachers of secondary and primary schools on the basis of natural, geographical and socio-economic peculiarities of development in one or another country to correctly present modern interdisciplinary environmental problems.

GLOSSARY OF BASIC TERMS

Areal — space within the boundaries of which one or another species (genus, family, etc.) occurs.

Plant species under threat of disappearance — the one whose number has been reduced to a dangerous level.

Anthropogenic effects — effects caused by man, also could be indirect.

Economic natural resource compensation — replacement of exhausted resources by an extensive search for their new sources.

Renewal of natural resources — their natural recovery in the course of natural processes.

Reproduction of natural resources — their artificial maintenance at a socially required qualitative and quantitative level or their large-scale procurement by technological means.

Degradation of soil — any (natural and anthropogenic) processes lowering the fertility of soil.

Environmental pollution — introduction into any environmental medium or appearance in it of new, usually uncharacteristic of it, physical or biological agents or increase in the concentration of the mentioned agents in the environment which exceeds at the time the natural average long-range level (goes beyond the limits of its extreme fluctuations).

Exhaustion of soil — impoverishment of its nutritious substances resulting from long exploitation without the application of fertilizer or due to insufficient application of fertilizer.

Environment — a concept including a complex of natural, created and social components in the life of mankind. The social components constitute a number of cultural, moral, personal values and relationships among people in work and recreation.

Devastation — loss of a continuous plant cover in a locality, not renewable without the help of man.

Irrigation — the artificial application of moisture to soil by means of supplying water from a water source.

Drainage — a complex of hydraulic-engineering and other measures for removing the surplus of water from soil.

Transformation of nature — anthropogenic changes in the established ecological balance for increasing the biological productivity or economic productivity of natural complexes.

Rational use of nature — the practice of using the natural media and resources not resulting in drastic changes and not causing changes harmful to the health or endangering the life of man as a biological being.

Biological productivity — biomass produced by a population of biotic community in a unit of area (or on the whole) per unit of time.

Economic productivity (of lands) — amount of products needed by people which can be

obtained from unit of land area (or on the whole) per unit of time.

Balance in the man-nature system — continuously changing relationship between the degree of exploitation of natural resources accessible at the given stage of development of productive forces and production relations, their availability and demand in human society.

Natural resources: 1) natural objects and phenomena used at the present time, in the past and in the future for direct and indirect consumption promoting the creation of material wealth, maintenance of conditions for the existence of mankind and improving the quality of life (resources of comfort, aesthetical resources, including nature phenomena);

2) bodies and forces of nature (natural benefits) whose social usefulness changes either positively or negatively as a result of man's labour; these bodies and forces are used (or potentially suitable for use) as a means of labour (land, waterways, water for irrigation), power sources (hydropower, nuclear fuel, deposits of fuel minerals), raw materials (minerals, forests, process water), an object of consumption (potable water, wild plants, mushrooms, sea products, flowers), recreation (rest places in nature, its health regenerative significance), genetic pool bank (resources of ecosystem reliability, breeding of new varieties and breeds) or sources of information on the surrounding world (major paleontological forms, reserves — standards of nature, bioindicators).

Formation of life medium — one of the forms of nature use directed to the creation of the most favourable living conditions for man.

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A NEW APPROACH TO STUDIES AND PROTECTION OF THE ENVIRONMENT

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